Vol. XXIII, Part I March, 1953

THE INDIAN JOURNAL OF AGRICULTURAL SCIENCE

Issued under the authority

of

The Indian Council of Agricultural Research

सत्यमेव जयते

Annual subscription
Rs. 15 or 23*s.* 6*d.*

Price per part
Rs. 4 or 6*s.* 6*d.*

PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI
PRINTED BY THE GOVERNMENT OF INDIA PRESS, CALCUTTA, INDIA
1953

CONTENTS

VOL. XXIII, PART I

(March, 1953)

The Publications Committee of the Indian Council of Agricultural Research, India, takes no responsibility for the opinions expressed in this Journal

ORIGINAL ARTICLES

RESPONSE OF CERTAIN VARIETIES OF WHEAT TO DIFFERENT FERTILITY LEVELS

By S. Sen, Assistant Wheat Breeder and B. P. Pal, Director, Indian Agricultural Research Institute, New Delhi

(Received for publication on 3 February 1953)

(With three text-figures)

CROP yield is the end result of interactions between the genetic constitution of the crop and the environmental factors of the place in which it is grown. The yield is, therefore, at its best when the plants are in harmony with the environment.

In breeding crop plants the important point with which the plant breeder is concerned is to evolve varieties with different genetic make-up which fit in well in the different localities for which improvement is sought for. This is best done by taking selections in local varieties or segregating populations in representative tracts instead of restricting the work to a single tract. Since facilities for such work do not exist in many places in this country, the general practice among plant breeders has been to send out a large number of selections and test them in different areas before finally choosing and releasing those that give good yields. These selections and yield trials are, however, carried out at a single level of soil fertility existing in the locality concerned. Since there are wide variations in the type and fertility of the soil in different States in the country, the performance of varieties evolved at any particular fertility level is likely to be different when they are tried at a place with a different soil type and fertility. Several experiments conducted recently have indicated that varieties of a particular crop differ in their response to different fertility levels of the soil. That this is not invariably so has, however, been brought out by the results obtained by some workers, who did not observe any significant difference between varieties in this respect. In certain cases seasonal effects rather than those of soil fertility were found to be quite pronounced. A few of the more important investigations in this connection are referred to here.

Fisher and Mackenzie [1923] worked on certain varieties of potato and did not find any significant difference in their response to manurial treatments. On the other hand, Gregory and Crowther [1928] observed the existence of differential varietal response to manuring in the pot-culture experiments conducted with five varieties of barley. The experiments of Mooers [1933] on corn also established the differential response of varieties to levels of fertility.

Stringfield and Salter [1934] reported the work done for five seasons on varieties of corn at four levels of fertility. They observed that, in general, yields were higher at higher levels and that differential varietal response in yield to fertility levels existed in two seasons only and not in the experiment as a whole. They further observed a highly significant interaction of varieties with seasons.

Lamb and Salter [1936] working on wheat concluded that different varieties responded differently to manurial doses. They, however, observed that seasonal factors influenced yield markedly and that the differences of yearly averages were greater than those between varieties in any one year.

Crowther [1938] conducted experiments with cotton varieties in Egypt under different levels of nitrogenous manures and established the differential response of varieties to manuring.

Hurst *et al.* [1939] working with two varieties of sugar beets at three levels of fertility did not observe any significant interaction between varieties and doses of fertilizers.

Worzella [1943] worked on wheat for five seasons and reported a differential response of varieties in yield to doses of fertilizers. Some varieties in his experiments yielded relatively highly on the well fertilized plots while others were more efficient on plots of low fertility. It was, however, observed that the highest yielding variety proved to be the best on all levels of fertility while the low-yielding varieties produced the least amount of grain on all levels. The interactions of varieties with doses of fertilizers in these experiments, although significant, were not big enough to change yield ranks of varieties. He further observed considerable effects of seasonal factors on varieties as well as manurial doses.

Barbacki and Saloni [1948] report that higher seed rate increased the yield of unmanured plots of spring cereals and N, P and K gave further increases, these being, however, small and almost independent of the variety. They observed seasonal effects to be much greater than any effect of manuring or variety in their experiments on cereals. This was, according to them, particularly true of oats.

In view of the above findings regarding the response of varieties of a particular crop to different levels of soil fertility, it is necessary to test them at a number of fertility levels before some of the varieties are finally picked out for release. The ideal method is to select plants in local varieties or segregating populations at different levels of soil fertility. In this connection Crowther [1938] has suggested that varieties should not only be tried on sites representative of the different soil types but the trials should include manurial factors also, not merely in the final tests but even in the early stages of selection. Pal and Parthasarathy [1950] also state "Varieties will thus have to be selected and tested under different levels of manuring related to the various soil types and only those which give maximum yields under optimum conditions released for distribution to farmers". Investigations in this direction are now under way at Indian Agricultural Research Institute and selections are being made in segregating progenies of a few crosses grown under different doses of fertilizers. These selections will be subjected to thorough yield tests and those which respond to high doses of manures will be multiplied for release.

In view of the recent improvements in the methods of cultivations and the prospects of availability of fertilizers in large quantities in this country, the practice of growing crops under heavily manured conditions should now be encouraged for stepping up the produce of the different crops. This method of heavily manuring the plots is already being followed in the case of cash crops like sugarcane, cotton,

etc. and should be adopted in food crops also. The breeder's task will, therefore, be to select varieties which respond to high levels of manuring.

Most of the crop varieties available in this country were evolved at a particular place under ordinary conditions of fertility of soil. In order to get the maximum benefit from the use of such varieties it is necessary to have an idea of their response to different environmental factors including those of soil fertility. With this end in view the present investigations were taken up to study, over a period of three consecutive seasons, the response of a few improved varieties of wheat to different doses of fertilizers.

Material and Method

The experiment was designed to study the response of certain varieties of wheat to different levels of fertility and was conducted during three consecutive seasons, *viz.* 1947-48, 1948-49 and 1949-50. There were two sets of factors in the experiment, varietal treatments and manurial treatments. The particulars of the varieties are given below.

(i) V_1 (*Pb. C. 518*). The variety was evolved in the Department of Agriculture, Punjab, by hybridization. It is of medium maturity and does best on rich, irrigated soils. It has a stiff straw and resists lodging very well. It is partially resistant to stripe rust and is quite suitable for north western parts of the country.

(ii) V_2 (*N.P. 165*). The variety was evolved at the Indian Agricultural Research Institute by hybridization. It is of very early maturity and gives very high yields under conditions of high fertility of the soil. It is partially resistant to stem rust and does well in various wheat tracts particularly in north western India.

(iii) V_3 (*N.P. 125*). The variety was evolved at the Indian Agricultural Research Institute by hybridization. It is of mid-early maturity and has good standing power. It does well in central and *Terai* areas in Uttar Pradesh.

(iv) V_4 (*N.P. 710*). The variety has recently been evolved at the Indian Agricultural Research Institute by hybridization. It is of mid-early maturity and is fairly resistant to rusts. It yields well under different climatic and soil conditions and is perhaps more adaptable than any other Indian variety of wheat. Although particularly suitable for north western India, it does fairly well in many other parts.

(v) V_5 (*N.P. 761*). The variety has recently been evolved at the Indian Agricultural Research Institute by hybridization. It is of very early maturity and is fairly resistant to leaf rust. On account of its extreme earliness it escapes damage by stem rust also. It does quite well in Orissa, Bihar and Eastern Uttar Pradesh.

(vi) V_6 (*mixture of all the five varieties*).

The six varietal treatments stated above were tested against four levels of soil fertility, *viz.* T_1, T_2, T_3 and T_4, the details of which are given below.

(*a*) T_1 (*maximum dose of fertilizers*). 80 lb. of nitrogen (40 lb. of organic nitrogen in the form of mustard cake and 40 lb. of inorganic nitrogen in the form of ammonium sulphate) + 160 lb. of phosphate in the form of superphosphate + 80 lb. of potash in the form of potassium sulphate per acre.

(*b*) T_2 (*half maximum dose of fertilizers*). Half of the quantities of fertilizers mentioned above (in T_1) per acre.

(*c*) T_3 (*nitrogen only*). 40 lb. of inorganic nitrogen in the form of ammonium sulphate.

(*d*) T_4 (*control*). No manure.

The two factors gave altogether (6×4) or 24 treatments. Each treatment was replicated three times giving a total of 72 ultimate plots each measuring (31 ft.×16 ft.) or 1/88 acre in area.

The experiment was laid out in the Division of Botany, Indian Agricultural Research Institute, in a plot measuring one acre. In order to have an idea of the soil type or types three pits were dug over the whole area and the profiles were examined by the Soil Survey Officer of this Institute before the experiment was laid out.

Except for salinity and phosphate contents, where variations occurred, the surface soil of the plot (0—4 in.) was remarkably uniform. Considerable variations were, however, noted in physical and chemical composition in the soil below the surface.

The plot was kept fallow during the *kharif* season in the three years when the experiment was conducted and no fertilizers were applied to it other than those required for the experiment.

As may be seen in the plan (Fig. 1) a split-plot layout with three replications was adopted for the experiment in which the varieties were whole-plot treatments and manures were sub-plot treatments. In all the three years when the experiment was conducted the different ultimate plots occupied exactly the same positions in the field so as to eliminate the chances of one treatment of a particular year vitiating by its residual effect, if any, the direct effects of some other treatment.

The fertilizers were applied to the different ultimate plots and mixed up thoroughly with the soil a few hours before the seeds were sown. The sowing was done by hand in furrows running at a distance of one foot and made by hand plough. In order to ensure similar stand in the ultimate plots attempts were made to sow equal number of seeds in each.

The number of grains in an ounce of seed of each variety was counted and the seed required for an ultimate plot was calculated on the basis of a seed rate of 40 seers to an acre of the lightest seed. In the case of V_6 (the mixture) an equal number of seeds of each of the five varieties was mixed up to give the weight required for an ultimate plot.

Bunds of about one foot in height were erected all round the ultimate plots so as to prevent the fertilizers being washed out during irrigation or rain.

The experiment was irrigated whenever it was considered necessary depending upon the rainfall. Three irrigations were given in the first year (on 16 October, 1 and 27 March), two in the second year (18 December and 1 March) and one in the third year (27 December).

When the crop was mature one row from either side of an ultimate plot and a border of one foot from the two other sides (shorter sides of the plot) were removed to eliminate border effect. The plants in each net plot (29 ft. × 14 ft.) were harvested and threshed and the weights of grain were recorded.

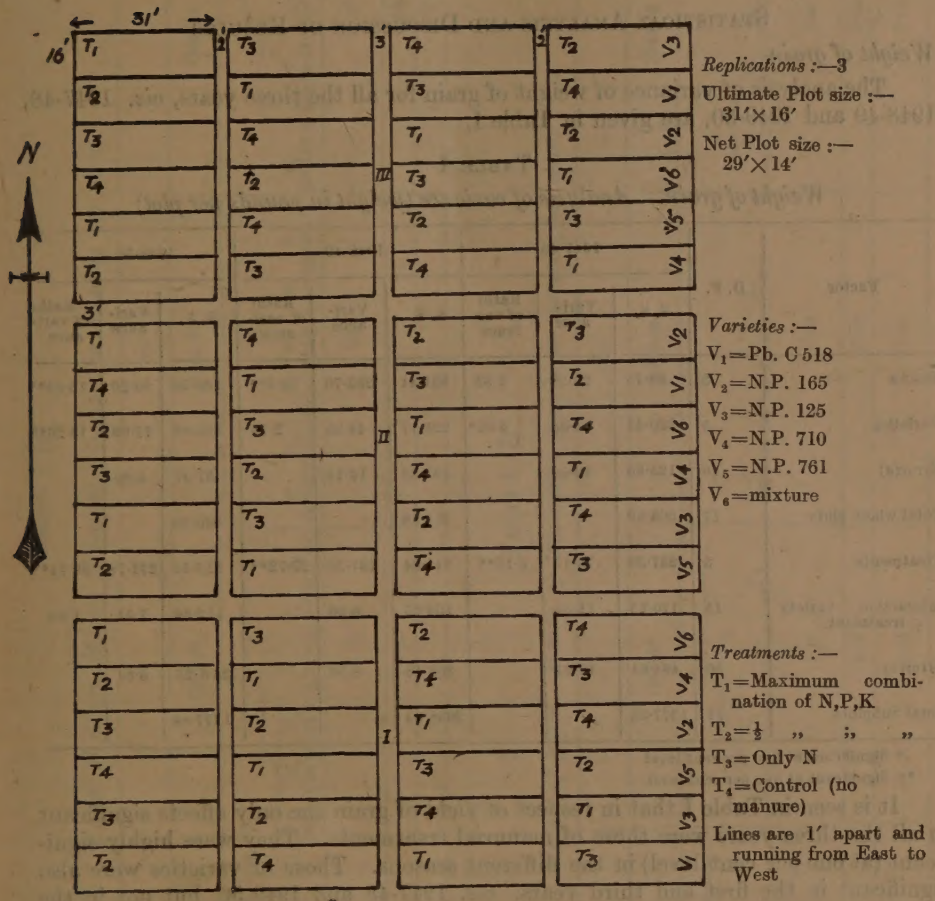


FIG. 1. Pl n of the experiment

Approximately equal quantities of grain were then taken from the produce of all the 72 plots of the experiment and those from the same variety-treatment combination in the three replications were thoroughly mixed. There were thus 24 composite samples from each of which one pound was taken for chemical analysis in connection with determination of percentage of nitrogen.

Statistical Analysis and Discussion of Results

Weight of grain

The analysis of variance of weight of grain for all the three years, *viz.* 1947-48, 1948-49 and 1949-50, are given in Table I.

Table I

Weight of grain. Analysis of variance (weight in pounds per plot)

Factor	D. F.	1947-48			1948-49			1949-50		
		S. S.	Variance	Ratio of variance	S. S.	Variance	Ratio of variance	S. S.	Variance	Ratio of variance
Blocks	2	58·75	29·38	2·33	531·41	265·70	16·4**	160·59	80·29	13·84**
Varieties	5	320·41	64·08	5·09*	221·77	44·35	2 74	385·08	77·02	13·26**
Error(*a*)	10	125·93	12·59		161·38	16·14		57·97	5·80	
Total whole plots	17	505·09			914·56			606·34		
Treatments	3	237·39	79·13	6·13**	711·84	237·28	27·72**	815·35	271·78	39·74**
Interaction variety × treatment	15	170·25	11·35		104·35	6·96		112·60	7·51	1·09
Error(*b*)	36	464·61	12·91		308·18	8·56		246·25	6·84	
Total Subplots	71	1377·35			2038·93			1777·84		

* Significant at five per cent level

** Significant at one per cent level

It is seen in Table I that in respect of yield of grain the only effects significant in all the three years were those of manurial treatments. They were highly significant (at one per cent level) in the different seasons. Those of varieties were also significant in the first and third years, *viz.* 1947-48 and 1949-50, but not in the second year. The average yields of varieties and treatments, for each year separately, together with the standard errors of means and critical differences are shown in Tables I (*a*) and I (*b*) respectively.

The interaction between varieties and treatments is not significant in any one of the three years. The table of interaction showing the mean weight of grain in maunds per acre of each combination of the two factors, varieties and treatments, is presented in Table I (*c*).

TABLE I (*a*)

Weight of grain. Means of varieties (weight in maunds per acre)

	Year		
	1947-48	1948-49	1949-50
Insignificant groups at 5 per cent level	V_3 V_2 V_1 V_4 V_5 V_6	V_4 V_5 V_6 V_1 V_2 V_3	V_1 V_4 V_2 V_5 V_3 V_6
	(25·15)(24·47)(21·41)(20·54)(18·72)(17·63)	(27·90)(27·04)(26·58)(24·37)(22·20)(22·16)	(35·11)(30·44)(29·46)(28·88)(26·21)(26·15)
S. E. of mean	1·33	1·51	0·90
C. D. at 5 per cent	4·21	—	2·82
C. D. at 1 per cent	—	—	4·00

'F' is not significant

TABLE I (*b*)

Weight of grain. Means of treatments (weight in maunds per acre)

	Year		
	1947-48	1948-49	1949-50
Insignificant groups at 5 per cent level	T_2 T_1 T_3 T_4	T_1 T_2 T_3 T_4	T_1 T_2 T_3 T_4
	(23·89) (23·07) (20·52) (17·84)	(30·54) (26·92) (23·10) (19·60)	(34·33) (32·84) (26·77) (23·55)
S. E. of mean	1·11	0·90	0·81
C. D. at 5 per cent	3·17	2·59	2·31
C. D. at 1 per cent	4·25	3·46	3·09

TABLE I (*c*)

Weight of grain. Variety × Treatment (weight in maunds per acre)

Treatment	Variety						S. E. of mean
	V_1	V_2	V_3	V_4	V_5	V_6	
1947-48							
T_1	27·70	28·36	20·42	15·75	26·62	19·56	
T_2	21·51	27·27	20·86	20·97	27·05	25·64	2·70
T_3	19·56	21·51	15·86	19·77	25·86	20·53	
T_4	16·84	20·75	13·36	18·58	21·08	16·41	
1948-49							
T_1	28·90	33·19	30·42	31·61	30·10	29·01	
T_2	24·77	29·88	25·26	29·93	23·09	28·57	2·20
T_3	22·49	24·61	19·23	26·89	20·21	25·15	
T_4	21·29	20·48	13·86	23·14	15·21	23·58	
1949-50							
T_1	37·70	36·40	32·32	33·47	31·08	34·98	
T_2	39·55	33·52	30·15	32·65	29·28	31·89	1·97
T_3	34·12	27·33	21·62	24·28	25·97	27·27	
T_4	29·12	30·59	20·72	25·10	18·20	27·55	

'F' is not significant

Varieties. The average yield of grain that was calculated for each individual year shows wide variations from year to year, the same being 21·33, 25·04 and 29·37 maunds per acre in 1947-48, 1948-49 and 1949-50 respectively (Table III(*c*)). These differences in yield indicate that the conditions for growth and development of the crop were most favourable in the last year and least in the first year, they being moderately so in the second year. Since the experiment was conducted not only in the same plot of land but the different combinations of varietal and manurial treatments in it occupied exactly the same position in the field in different years, the differences in yield may be attributed to differences in climatic factors, such as temperature, humidity and rainfall, of which the first one was perhaps the most important. As in the case of average yield of grain in the experiment and also for the same reasons stated, there is a gradual rise from the first to the second and then to the third year, in the yield of each individual variety. The only exception was that of V_5 (N. P. 761) which registered a fall in yield in the second year. This unusual behaviour of the variety is rather difficult to explain.

As may be seen in Table I(*a*), there was considerable difference in the results of the different years with regard to the average yield of grain of varieties. The positions occupied by most of them, in order of weight of grain, were also quite

different in the three years. In the first year V_5 (N. P. 761) gave the maximum yield, followed closely by V_2 (N. P. 165) and V_1(C. 518), the differences between them being not significant. The other three varieties came after them in the order, V_6 (mixture), V_4 (N.P. 710) and V_3 (N.P. 125). At the five per cent level of significance, V_5 was found to be superior to V_6, V_4 and V_3 ; and the variety V_2 to V_4 and V_3. At the one per cent level of significance, however, the varietal effects were not found to be significant. In the second year, V_4 out-yielded the others, and was followed closely by V_2, V_6, V_1 and V_3 and V_5 respectively. The differences between them, however, were not significant even at the five per cent level of significance. In the last year, highly significant differences were observed between the effects of varieties. V_1 gave the maximum yield and was followed by V_6, V_2, V_4, V_3 and V_5 respectively. At the five per cent level of significance, V_1 was found to be superior to all others, and both V_5 and V_6 were superior to V_3 and V_5. At the one per cent level of significance, V_1 was found to be better than the others, and V_6 than both V_3 and V_5.

Of the six varieties, V_2, V_3 and V_6 occupy more or less similar positions in order of yield, in different years, although there were wide differences in the actual yields. V_2 occupied the second place in the first and second years, and third place in the third year. V_3 was the poorest yielder in the first year and occupied the fifth place in the second and third years. V_6 occupied the fourth, third and second places in the first, second and third years respectively.

With regard to actual yield of grain, the variety V_1 (C. 518) was most affected due perhaps to variations in climatic factors and it showed a rise from 21·41 md. per acre in the first year to 35·11 md. in the third year when the season appeared to be most favourable. V_4 (N.P. 710) was next to V_1 in this respect, showing a difference of 10·16 md. between the yields of the first and the third years. This was followed by V_6(mixture) and V_3(N.P. 125), the difference between the yields of the first and the third years in these cases being 9·90 md. and 8·58 md. respectively. In V_2 (N.P. 165) the difference was 4·99 md. and in V_5 (N.P. 761) only 1·0 md.

It is evident from the above that the two varieties, V_5 (N. P. 761) and V_2 (N.P. 165) were, as compared with others, much less affected by climatic factors, although there has been some increase in the yields from the first to the third year, except the unusual drop in the second year in the case of V_5 (N. P. 761). The fairly consistent performance (with regard to yield of grain) of the two varieties was perhaps due to their very early maturing habit. The comparatively unfavourable growing season in the first year did not bring down the yield of varieties which had shorter growing period to any considerable extent, since they had, when the unfavourable climatic conditions set in, already passed that stage of development of the plant when the yield could be adversely affected. Of these two varieties, N. P. 761 being earlier is perhaps less affected than N. P. 165. V_1 (C. 518), V_4 (N .P. 710) and V_3 (N. P. 125) have a longer growing period and hence could not escape the adverse effects of climate and yielded much less in the first year than in the second or the third year, particularly the latter. The last variety, V_6 (mixture),

also showed considerable variations in the yield of grain in different years, there being, as in other cases, a gradual rise from the first to the third year. Since V_6 was a mixture of equal number of seeds of five varieties, of which three were, as has already been observed, much affected by fluctuations in climatic factors, this varietal treatment, on the whole, also showed considerable variations in yield.

Manurial treatments. It is seen in Table I(*b*) that the average effects of manurial treatments, so far as the positions of different treatments are concerned, were slightly more consistent than those of varieties in different years ; particularly they were so in the second and third years. There was, however, considerable variation in the three years with regard to significance of difference between the four treatments. As has already been indicated in the Table I (*b*), T_2 gave the best results in 1947-48, followed by T_1, T_3 and T_4 in that order. At the five per cent level of significance, T_2 was found to be better than both T_3 and T_4, and T_1 better than T_4 only. At the one per cent level of significance, on the other hand, T_2 and T_1 were superior to T_4. In the second year, T_1 was found to be the best among the four manurial treatments, followed by T_2, T_3 and T_4 respectively. At the one per cent level of significance, each one of them was better than all others following it. In the third year, the position of the treatments, in order of weight of grain, was the same as in the second year. At both the levels of significance (five per cent and one per cent), T_1 and T_2 were on par and were superior to the others, *viz.* T_3 and T_4, the difference between the last two being also significant.

Interaction. The interaction between varieties and manurial treatments has already been observed to be insignificant in all the three years, showing thereby that the varieties did not respond significantly differently to the different doses of manures used. The weights of grain for different combinations of variety and treatment given in Table I(*c*) indicate that although there were considerable differences between the actual yields of six varietal treatments with a particular manurial dose, a similar tendency exists in the performance of the varieties at different levels of fertility.

It is seen that in the first year (1947-48), V_1 and V_2 have given the maximum yields of grain at T_1 and the minimum at T_4. There is a fall in the yields of these varieties along with the reduction in the quantity of fertilizers applied. In the case of V_3, V_4, V_5 and V_6 there is a rise from T_1 to T_2, the highest yield being obtained at the latter after which there is a gradual fall. The differences between T_1 and T_2 with regard to varieties V_3 and V_5 are, however, found to be very small. In V_6, on the other hand, the increase in yield from T_1 to T_2 is considerable and then there is a gradual fall to T_3 and T_4. The variety V_6 also behaves similarly, but in this case the yield at T_1 is less than at T_4.

In 1948-49 the different varieties behaved very similarly in respect of their response to the four manurial treatments and gave the highest yields at T_1 after which there was a reduction.

In the year, 1949-50, V_1 showed an increase from T_1 to T_2, the latter giving the best yield. After this there was a gradual fall upto T_4 which recorded the minimum yield. All other varieties are found to have behaved more or less similarly and gave the best yields at T_1 followed by T_2 and T_3 in that order. V_2, V_4 and V_6 showed

some increase at T_4 as compared with T_3, whereas in the cases of V_3 and V_5 the lowest yields were obtained at T_4.

Weight of whole plant (grain and straw)

The analyses of variance of weight of whole plant for two years, 1948-49 and 1949-50 are presented in Table II.

TABLE II

Weight of whole plant. Analysis of variance (weight in pounds per plot)

Factor	D.F.	1948-49			1949-50		
		S.S.	Variance	Ratio of variance	S.S.	Variance	Ratio of variance
Blocks	2	9500·37	4750·19	19·21**	2995·03	1497·52	19·15**
Varieties	5	2963·07	592·61	2·40	1247·95	249·59	3·19
Error (*a*)	10	2473·30	247·33		781·80	78·18	
Total whole plots	17	14936·74	878·63		5024·78	295·58	
Treatments	3	12701·16	4233·72	62·87**	12904·89	4301·63	56·66**
Interaction variety × treatment	15	955·76	63·72		1846·94	123·13	1·78
Error (*b*)	36	2424·33	67·34		2685·27	74·59	
Total sub-plots	71	31017·99			22461·78		

** Significant at one per cent level

The above table indicates that, in the case of whole plant weight, the effects of manurial treatments are significant in both the years, the varietal effects being, however, insignificant. The average weights in the case of both the factors, varieties and treatments, separately for each year, are shown in Tables II(*a*) and II(*b*) respectively.

As in the case of grain yield, the interaction between varieties and treatments in this case has not come out significant in any one of the two years. The statement of interaction showing the weight of whole plant in maunds per acre of each combination of the two factors is given in Table II (*c*).

TABLE II(*a*)

Weight of whole plant. Means of varieties (weight in maunds per acre)

Insignificant groups at 5 per cent level	Year											
	1948-49						1949-50					
	V_6 (100·40)	V_4 (98·01)	V_1 (90·51)	V_2 (88·23)	V_5 (85·62)	V_3 (74·97)	V_1 (107·46)	V_6 (106·05)	V_5 (96·70)	V_3 (95·62)	V_2 (94·64)	V_4 (94·53)
S. E. of mean	5·92						3·32					
C. D. at 5 per cent	—						—					
C. D. at 1 per cent	—						—					

'F' is not significant in either year

TABLE II(*b*)

Weight of whole plant. Means of treatments (weight in maunds per acre)

Insignificant groups at 5 per cent level	Year							
	1948-49				1949-50			
	T_1 (113·51)	T_2 (96·49)	T_3 (81·64)	T_4 (66·86)	T_1 (121·48)	T_2 (109·89)	T_3 (88·16)	T_4 (77·15)
S. E. of mean	2·52				2·66			
C. D. at 5 per cent	7·22				7·63			
C. D. at 1 per cent	9·69				10·21			

TABLE II (*c*)

Weight of whole plant. Variety × Treatment (weight in maunds per acre)

Treatment	Variety						S. E. of mean
	V_1	V_2	V_3	V_4	V_5	V_6	
1948-49—							
T_1	106·47	115·16	104·29	117·33	115·16	122·55	
T_2	90·39	99·95	82·57	107·77	94·74	103·43	6·18
T_3	86·91	76·48	65·19	92·56	76·92	91·69	
T_4	78·22	61·27	47·80	74·31	55·62	83·87	
1949-50—							
T_1	117·77	117·77	119·51	120·81	120·38	132·54	
T_2	116·46	112·12	105·60	110·82	111·25	102·99	6·50
T_3	105·17	85·18	82·57	72·57	89·96	93·43	
T_4	90·39	63·45	70·40	78·22	65·19	95·17	

'F' is not significant

Varieties. It may be seen in Table II(*a*) that in 1948-49, V_6 gave the best result followed closely by V_4. V_1, V_2, V_5 and V_3 followed these two in that order. In the next year, 1949-50, however, the positions occupied by the varieties were found to be different, V_1 standing first. It was followed very closely by V_6, the others coming after it being V_5, V_4, V_2 and V_3 respectively. The differences between the varieties were not significant in any year.

Treatments. Table II (*b*) indicates that there is a great deal of similarity in the results obtained in the two years, both in regard to positions of different manurial treatments and the significance of difference between them. T_1 has been found to be the best among the four, followed by T_2, T_3 and T_4 respectively. At both the levels of significance (five per cent and one per cent) each one of the manurial treatments was found to be better than those following it.

Interaction. The interaction between varieties and treatments has already been observed to be insignificant statistically. The actual weights of whole plants for different combinations of variety and treatment given in Table II(*c*) appear to differ considerably. The maximum yield is seen to have been obtained in both the years, *viz.* 1948-49 and 1949-50, by the combination of V_6 (mixture) and T_1 (maximum dose) which is followed by V_4 (N.P.710) T_1. The poorest yields, on the other hand, have been given by the combinations, V_3 (N. P. 125) T_4 (no manure) and V_2 (N.P. 165) T_4 in 1948-49 and 1949-50 respectively. In spite of the above differences, the insignificant value of ratio of variance in Table II indicates

that there is no significant difference in the responses of varieties to the various doses of manures in respect of the character in question.

Combined analysis

Weight of grain

As the error variances of weight of grain were found to be homogeneous in the three years, the data were pooled and a combined analysis worked out, taking year (season) as one of the factors. The analysis of variance is given below in Table III.

Table III

Weight of grain (three years). Combined analysis

Analysis of variance (weight in pounds per plot)

Factor	D. F.	S.S.	Variance	Ratio of variance
Blocks	2	391·6881	195·84	9·74**
Varieties	5	368·9077	73·78	3·67*
Error (*a*)	10	201·0853	20·11	
Treatments	3	1616·1483	538·72	33·99**
Interaction Variety × treatment	15	180·3577	12·02	
Error (*b*)	36	570·7063	15·85	
Years	2	1373·0708	686·54	69·3**
Interaction Variety × Year	10	558·3414	55·83	5·6**
Interaction Treatment × Year	6	148·4286	24·74	2·5*
Interaction Variety × Treatment × Year	30	206·8564	6·90	
Error (*c*)	96	951·5920	9·91	
Total	215	5667·1826		

* Significant at five per cent level
** Significant at one per cent level

There are three different error variances, each of which is used for testing the various main effects and interactions which are shown just above it.

It is seen in Table III that, among the main effects, those of varieties are significant at five per cent level and those of manures and years at both five per cent and one per cent levels of significance. The mean yields of grain in maunds per acre in the case of all the three factors are given in Tables III(*a*), III(*b*) and III(*c*) along with the standard errors of means and critical differences.

Table III(*a*)

Weight of grain (three years). Combined analysis

Means of varieties (weight in maunds per acre)

Insignificant groups at five per cent level	V_2 (26·99)	V_1 (26·96)	V_6 (25·85)	V_4 (25·18)	V_5 (24·48)	V_3 (22·01)
S. E. of mean	0·97					
C. D. at five per cent	3·07					
C. D. at one per cent	—					

TABLE III(*b*)

Weight of grain (three years). Combined analysis
Means of treatments (weight in maunds per acre)

Insignificant groups at five per cent level	T_1 (29·31)	T_2 (27·88)	T_3 (23·46)	T_4 (20·33)
S. E. of mean	0·71			
C. D. at five per cent	2·03			
C. D. at one per cent	2·72			

TABLE III(*c*)

Weight of Grain (three years). Combined analysis
Means of years (weight in maunds per acre)

Insignificant groups at five per cent level	1949-50 (29·37)	1948-49 (25·04)	1947-48 (21·33)
S. E. of mean	0·48		
C. D. at five per cent	0·95		
C. D. at one percent	1·25		

Varieties. The mean grain yields of different varieties in Table III(*a*) indicate that V_2 has given the maximum yield (26·99 md.) followed very closely by V_1 (26·96 md.), the difference between the two being very small. The other varieties follow the first two in the order, V_6, V_4, V_5 and V_3. As regards the significance of difference between the varieties, those occupying the first five positions come in the same insignificant group. V_3, the last among the varieties in grain yield, is significantly inferior to the first four, its difference with V_5 being, however, insignificant.

The variety V_2 (N. P. 165), although not the best yielder in any one of the years, has, as compared to others, shown a consistently good performance throughout the entire three-year period, and as such, has topped the list in the combined analysis. The second variety, V_1 (C. 518), occupied the third, fourth and first positions in the years, 1947-48, 1948-49 and 1949-50 respectively. Nevertheless it has proved to be much better than the four other varieties and has given almost the same grain yield as V_2 (N. P. 165) in the combined analysis.

Treatments. So far as the manurial treatments are concerned, it is seen in the table of mean yields above (Table III-(*b*)) that, T_1 (maximum dose) has given the best yield of grain, followed by T_2 (half maximum dose), T_3 (nitrogen) and T_4 (no manure) in that order. Although the difference between the first two is insignificant, the other differences are significant at both five per cent and one per cent

levels. The mean yields of treatments show that with higher doses of manures there is an increase in the weight of grain, the increases from T_4 to T_3 and T_3 to T_2 being quite large.

Years. In the case of years (seasons) the effects have been observed to be highly significant (Table III). The average grain yields of years given above in Table III(*c*) indicate that the differences between them are very wide, the first year giving the poorest yield and the last year the highest, the second year coming in between. The difference between any two years is seen to be significant both at five per cent and one per cent levels. This indicates that the climatic conditions in 1949-50 were most favourable for the growth and development of the crop and those in 1947-48 were least favourable, they being moderately so in the second year.

Interactions. As may be seen in the combined table of analysis of variance (Table III), the interaction between variety and treatment is insignificant, which indicates that the varieties do not respond differently to the manurial doses. This confirms the results obtained in the case of individual years. The interactions, year × variety and year × treatment are, however, observed to be significant, the former at both five per cent and one per cent levels of significance and the latter at five per cent only. The three tables of interaction are given below (Tables III (*d*), III (*e*) and III (*f*)). The only interaction of the second order, *viz.* variety × treatment × year has not come out significant and has not, therefore, been discussed.

TABLE III(*d*)

Weight of grain (three years). Combined analysis
Variety × Treatment (weight in maunds per acre)

Varieties	Treatments			
	T_1	T_2	T_3	T_5
V_1	31·44	28·62	25·40	22·42
V_2	32·66	30·23	24·49	20·61
V_3	27·73	25·43	18·91	15·99
V_4	26·95	27·86	23·66	22·28
V_5	29·27	26·48	24·02	18·17
V_6	27·86	28·71	24·33	22·52
S. E. of mean	1·73			

'F' is not significant

TABLE III(*e*)

Weight of grain (three years). Combined analysis
Variety × Year (weight in maunds per acre)

Years	Varieties					
	V_1	V_2	V_3	V_4	V_5	V_6
1947-48	21·41	24·47	17·63	18·72	25·15	20·54
1948-49	24·37	27·04	22·20	27·90	22·16	26·58
1949-50	35·11	29·46	26·21	28·88	26·14	30·44
S. E. of mean						1·1849
C. D. at five per cent between two years for a particular variety						2·32
C. D. at one per cent between two years for a particular variety						3·06
C. D. at five per cent for other comparisons						3·81
C. D. at one per cent for other comparisons						5·01

TABLE III(*f*)

Weight of Grain (three years). Combined analysis
Treatment × Year (weight in maunds per acre)

Years	Treatments			
	T_1	T_2	T_3	T_4
1947-48	23·07	23·89	20·52	17·84
1948-49	30·54	26·92	23·10	19·60
1949-50	34·33	32·84	26·77	23·55
S. E. of mean				0·97
C. D. at five per cent between two years for a particular treatment				1·90
C. D. at five per cent for other comparisons				2·94

Variety × treatment. Although the interaction between variety and treatment has not been found to be significant, a study of Table III(*d*) gives a comparative idea of grain yield of different combinations of the two factors in the pooled analysis. V_2 (N.P. 165) T_1 (maximum dose) is found to have given the highest yield, followed by the combinations, V_1 (C. 518) T_1, V_2 T_2 (half maximum dose), V_5 (N.P. 761) T_1, in that order, the minimum yield being obtained by V_3 (N.P. 125) T_4 (no manure). The performance of the varieties at different levels of fertility is represented graphically in Fig. 2.

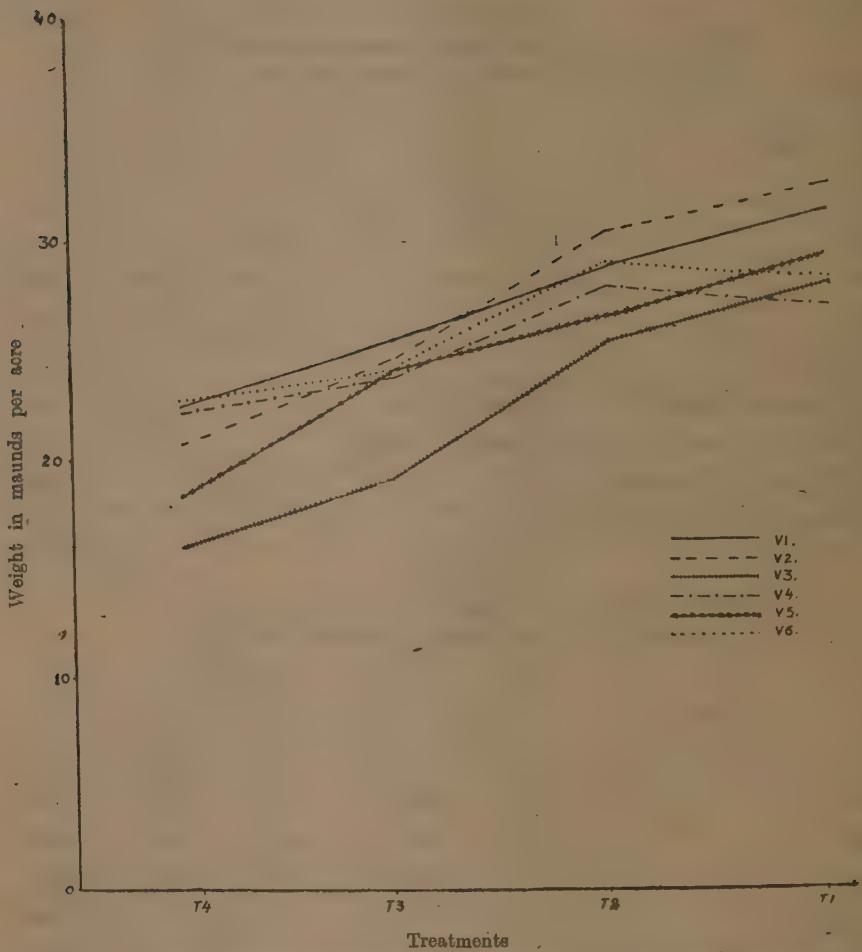


FIG. 2. Graph showing interaction variety × treatment (combined data)—grain weight

There is, as is clear from the above figure, a considerable degree of similarity in the response of different varieties to the doses of fertilizers. In the case of each variety the minimum yield was obtained at T_4, and from this there was some rise to T_3 and from the latter to T_2. In V_4 and V_6 the maximum yields were obtained at T_2 after which the graphs show a slight fall at T_1. In the other varieties, however, the maximum yield was obtained at T_1 and hence there is no fall of the graph at this level but a gradual rise to it from T_4 which recorded the lowest weight.

In spite of the differences in grain yield referred to above, there is a similarity in the response of varieties to the various fertility levels. These results seem to

agree with the observations of Fisher and Mackenzie [1923] on potatoes, Stringfield and Salter [1934] on certain corn varieties, and Hurst *et al.* [1939] on sugar beets.

Variety × *year.* It has already been observed that the interaction between the years and varieties is highly significant. Table III(*e*) shows that the maximum yield of grain has been obtained by the variety V_1 (C. 518) in 1949-50, followed by V_6 (mixture), V_2 (N.P. 165), V_4 (N.P. 710), etc. all in the same year, in that order. The minimum yield has been obtained by the variety V_3 (N.P. 125) in 1947-48. Among these, significant difference at five per cent level has been observed between the first and the second. The differences of the first with all others were, however, significant both at five per cent and one per cent levels. The superiority of the second to the third one and of the latter to the fourth one has not come out significant.

The results obtained in this experiment regarding the variations in the effects of varieties in different years are more or less similar to those obtained by Stringfield and Salter [1934], Lamb and Salter [1936], Worzella [1943] and Barbacki and Saloni [1948] who found considerable differences in the performance of varieties of different crops in different seasons.

Treatment × *year.* As has already been observed, the interaction between year and treatment is significant at five per cent level only. The interaction Table III(*f*) indicates that T_1 in 1949-50 has given the best results followed by T_2 in the same year; T_1 in 1948-49, T_2 in 1948-49, T_3 in 1949-50, etc. coming after them in that order. Among these combinations, the differences in the yields of the first from the third and of the second and third from the fourth and fifth are found to be statistically significant. The differences between the second and third, and between the fourth and fifth are, however, insignificant.

TABLE IV

Weight of whole plant, (two years). Combined analysis of variance (weight in pounds per plot)

Factor	D. F.	S.S.	Variance	Ratio of variance
Blocks	2	11149·5417	5574·7709	
Varieties	5	3064·3125	612·8625	2·75
Error (a)	10	2226·9583	222·6958	
Treatments	3	25462·7986	8487·5995	83·3**
Interaction Variety × treatment	15	2202·8264	146·8551	1·44
Error (*b*)	36	3666·5000	101·8472	
Year	1	1928·6736	1928·6736	24·3**
Interaction Variety × year	5	1146·7014	229·3403	2·88*
Interaction Treatment × year	3	143·2431	47·7477	
Interaction Variety × treatment X Year	15	599·8819	39·9921	
Error (*c*)	48	3817·0000	79·5208	
Total	143	55408·4375		

* Significant at five per cent level
** Significant at one per cent level

Weight of whole plant

Just as in the case of grain yield, the error variances in the analyses of variance of whole-plant weight in the two different years were found to be homogeneous, and therefore the combined analysis was worked out. The statement of analysis of variance is given in Table IV on the last page.

It is seen in Table IV that the main effects of varieties are insignificant as was the case in individual years and those of treatments and years are significant at one per cent level. The average weights of whole plant in the case of the three factors are given in Tables IV(*a*), IV(*b*) and IV(*c*) with the appropriate standard errors and critical differences.

Table IV(*a*)

Weight of whole plant (two years). Combined analysis
Means of varieties (weight in maunds per acre)

	V_6	V_1	V_4	V_2	V_5	V_3
Insignificant groups at five per cent level	(103·22)	(98·99)	(96·81)	(91·43)	(91·16)	(84·75)
S. E. of mean	3·97					

'F' is not significant

Table IV(*b*)

Weight of whole plant (two years). Combined analysis
Means of treatments (weight in maunds per acre)

	T_1	T_2	T_3	T_4
Insignificant groups at five per cent level	(117·49)	(103·19)	(84·90)	(72·00)
S. E. of mean	2·19			
C. D. at five per cent level	6·39			
C. D. at one per cent level	8·46			

Table IV(*c*)

Weight of whole plant (two years). Combined analysis
Means of years (weight in maunds per acre)

	1949-50	1948-49
Insignificant groups at five per cent level	(99·17)	(89·62)
S. E. of mean	1·37	
C. D. at five per cent	3·90	
C. D. at one per cent	5·20	

Varieties. Although the varietal effects are not significant, V_6 (mixture) has given the best result followed by V_1, V_4, V_2, V_5 and V_3 in that order.

Treatments. The results shown in Table IV(*b*) are quite similar to those of grain yield, T_1 giving the maximum weight of whole plant, followed by T_2, T_3 and T_4 in that order. The difference between any two treatments is highly significant. This indicates that with higher doses of manure the weight of whole plant also increased correspondingly, the increase from T_3 to T_2 being, however, more than in other cases.

Years. It is seen in Table IV(*c*) that the weight of whole plant in 1949-50 is significantly more than that of 1948-49. This is also similar to the results obtained in the case of grain yield where the last year gave the highest yield.

Interactions. The combined table of analysis of variance for whole plant weight (Table IV) shows that the only significant interaction is that between year

TABLE IV(*d*)

Weight of whole plant (two years). Combined analysis
Variety × Treatment (weight in maunds per acre)

Varieties	Treatments			
	T_1	T_2	T_3	T_4
V_1	112·13	103·44	96·05	84·32
V_2	116·48	106·05	80·84	62·37
V_3	111·92	94·10	73·89	59·11
V_4	119·09	109·31	82·58	76·28
V_5	117·78	103·01	83·45	69·41
V_6	127·56	103·22	92·58	89·53
S. E. of mean	5·37			

'F' is not significant

TABLE IV(*e*)

Weight of whole plant (two years). Combined analysis
Variety × Year (weight in maunds per acre)

Years	Varieties					
	V_1	V_2	V_3	V_4	V_5	V_6
1948-49	90·51	88·23	74·97	98·01	85·62	100·40
1949-50	107·46	94·64	94·53	95·62	96·70	106·05
S. E. of mean						3·36
C. D. at five per cent between two years for a particular variety						9·55
C. D. at five per cent for other comparisons						13·16

and variety (at five per cent level). The interactions, variety × treatment, treatment × year and variety × treatment × year are found to be statistically insignificant. The tables of the three different interactions of the first order are given in (Tables IV(*d*), IV(*e*) and IV(*f*)).

TABLE IV(*f*)

Weight of whole plant (two years). Combined analysis
Treatment × Years (weight in maunds per acre)

Years	Treatments			
	T_1	T_2	T_3	T_4
1948-49	113·51	96·49	81·64	66·86
1949-50	121·48	109·89	88·16	77·15
S. E. of mean	2·74			

'F' is not significant

Variety × treatment. The insignificant interaction between variety and treatment in the case of whole plant indicates, as in the case of grain yield, that the different varieties do not respond differently to the manurial doses. Table IV(*d*) shows that the best combination of variety and treatment is V_6 (mixture) and T_1 (maximum dose), followed by V_4 (N.P. 710) T_1, V_5 (N.P. 761) T_1, V_2 (N. P. 165) T_1 etc. in that order. The performance of the varieties at different fertility levels is indicated graphically in Fig. 3.

It is clear from Fig. 3 that there is a great similarity in the behaviour of the varieties at the four levels of fertility. In every case the minimum weight was recorded at T_4, and, from this there was a rise to T_3, and, from the latter to T_2 and then to T_1, the last level giving the maximum weight. Although there appears to be some difference between certain varieties with regard to the rise in the curves (*i.e.*, rate of increase in weight), there is no doubt that the response of the varieties to different doses of manures has been very similar.

Variety × year. As has already been stated, this is the only interaction that has come out significant in the case of whole plant. It is seen in Table IV(*e*) (table of interaction between variety and year) that V_1 (C. 518) in 1949-50 has given the best result, and has been closely followed by V_6 (mixture) in the same year ; the others following them being V_6 and V_4 (N.P. 710) in 1948-49, V_5 (N.P. 761) and V_4 in 1949-50, etc. in that order. The differences between these combinations are, however, insignificant. The variety, V_1, in 1948-49 has occupied the ninth position (whole plant weight of 90·51 md. per acre) and is found to be significantly inferior to the first and the second. The minimum weight has been recorded by V_3 (N.P. 125) in 1948-49.

Treatment × *year*. As has been seen in Table IV, the interaction, treatment × year is insignificant. Table IV (*f*), however, shows that, of the different combinations, T_1 (maximum dose) in 1949-50 has been the best ; the others following it in the sequence, T_1 in 1948-49, T_2 (half maximum dose) in 1949-50, T_2 in 1948-49, etc. The minimum weight has been obtained by T_4 (no manure) in 1948-49.

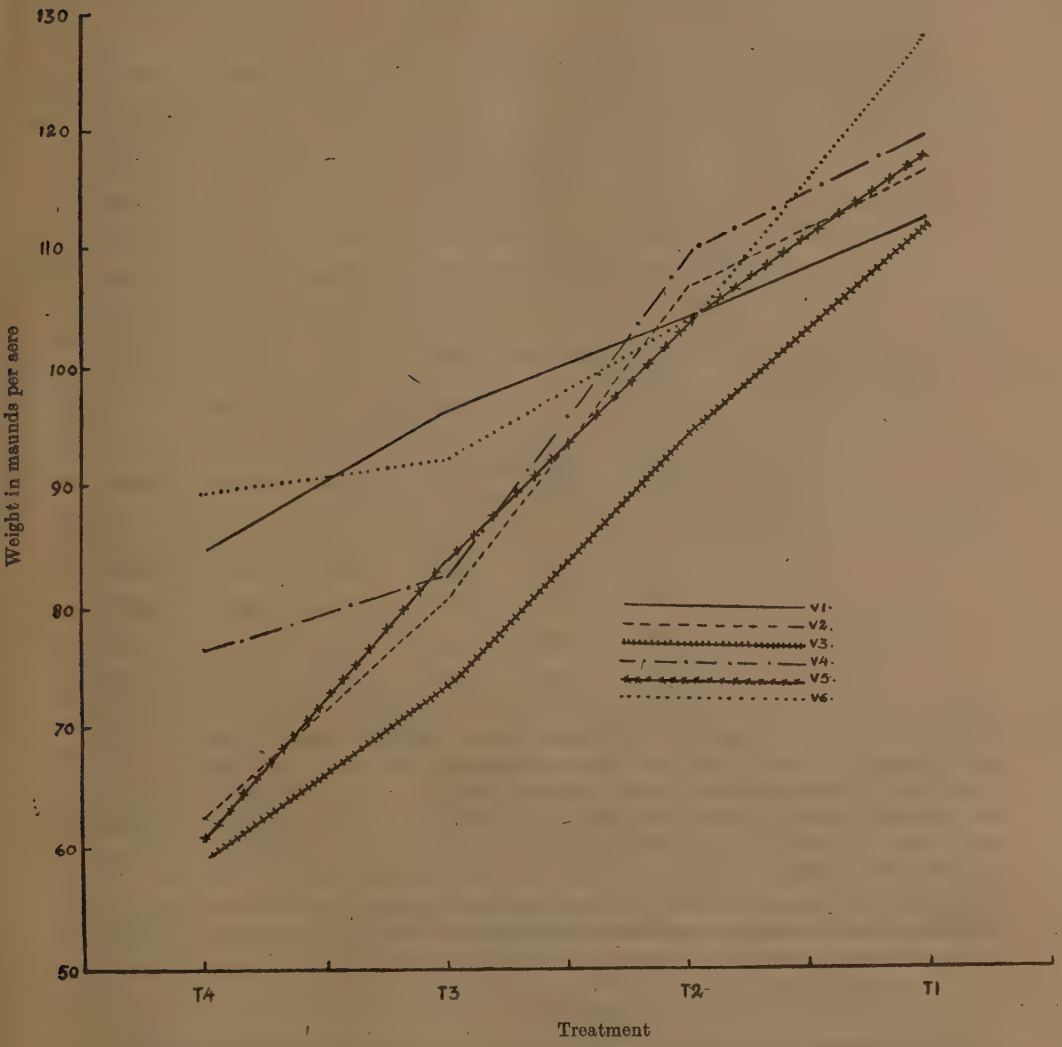


Fig. 3. Graph showing interaction variety × treatment (combined data)—Weight of whole plant

Percentage of nitrogen in seeds

The percentages of nitrogen in different samples of seed are given in Table V.

TABLE V

Percentage of nitrogen in seed

Treatment	Variety					
	V_1	V_2	V_3	V_4	V_5	V_6
1947-48—						
T_1	1·56	1·96	1·38	1·84	2·49	2·27
T_2	1·67	1·82	1·42	2·04	2·08	1·58
T_3	1·90	1·73	1·28	2·01	2·07	2·16
T_4	1·84	1·79	1·31	1·98	1·92	1·94
1948-49—						
T_1	1·77	1·90	1·42	1·85	2·12	2·02
T_2	1·51	1·79	1·35	1·94	1·77	1·52
T_3	1·58	1·87	1·86	1·99	2·01	1·97
T_4	1·65	1·89	1·35	1·80	2·03	1·98
1949-50—						
T_1	2·03	2·10	1·64	1·83	2·34	2·13
T_2	1·78	1·96	1·42	1·94	2·03	1·93
T_3	1·78	2·10	1·55	2·12	2·26	1·95
T_4	1·71	2·09	1·29	1·70	2·41	2·04

It is seen in above table that there is a considerable degree of variation not only between the three years but within a particular year also with regard to the percentages of nitrogen in the seeds of the varieties grown at four levels of fertility. The over-all averages for the varieties as calculated from the three-year data are 1·73, 1·92, 1·45, 1·92, 2·13 and 1·96 for V_1, V_2, V_3, V_4, V_5 and V_6 respectively. With regard to the treatments they are 1·93, 1·75, 1·91 and 1·82 for T_1, T_2, T_3 and T_4 respectively. It appears from these results that the percentages of nitrogen, and therefore of protein also, do not bear any appreciable relation to the manurial doses in the experiment which were applied to the plots before sowing of seeds.

SUMMARY

The experiment was conducted during three consecutive seasons to study the response of six varietal treatments, *viz.*, C. 518 (V_1), N.P. 165 (V_2), N.P. 125 (V_3),

N.P. 710 (V_4), N.P. 761 (V_5) and a mixture of the five varieties (V_6) to four levels of fertility which were maximum doses of N, P and K, (or T_1), half of these quantities (T_2), only N (T_3) and the control (T_4).

With regard to yield of grain, the overall effects of manurial doses were highly significant in all the three years and those of varieties were significant in the first and the third years.

There was considerable variation in the actual yields and in the position of different varieties due to differences in climatic conditions in the three years. However, the insignificant groups (at five per cent level) among the varieties in 1947-48, 1948-49 and 1949-50 were $\underline{V_5\ V_2\ V_1}\ V_6\ V_4\ V_3$, $\underline{V_4\ V_2\ V_6\ V_1\ V_3\ V_5}$ and $V_1\ \underline{V_6\ V_2\ V_4}\ V_3\ V_5$ respectively. There was some variation in the effect of manurial treatments also, but it was less marked than that of varieties. The insignificant groups among the manurial treatments in the three years were $\underline{T_2\ T_1}\ T_3\ T_4$, $T_1\ T_2\ T_3\ T_4$ and $\underline{T_1\ T_2}\ T_3\ T_4$ respectively.

In the case of the weight of whole plant, the effects of manurial treatments were significant in both the years. The insignificant groups (at five per cent levels) in both the years (1948-49 and 1949-50) were $T_1\ T_2\ T_3\ T_4$. The differences between varieties were not significant in either year.

The interaction of varieties with manurial treatments did not come out significant in any year either in the case of grain weight or whole-plant weight.

In the combined analysis based on the pooled data of all the years, the effects of varieties, manurial treatments and years were found to be significant in regard to yield of grain. The insignificant groups among varieties were $\underline{V_2\ V_1\ V_6\ V_4\ V_5}\ V_3$, among manurial treatments, $\underline{T_1\ T_2}\ T_3\ T_4$, and among years, 1949-50, 1948-49, 1947-48.

With regard to the weight of whole-plants, manurial treatments and years came out significant in the combined analysis. The insignificant groups in the case of treatments were $T_1\ T_2\ T_3\ T_4$, and in that of years, 1949-50, 1948-49.

The interactions found significant in grain yield were variety × year and treatment × year, and in the case of whole-plant weight, variety × year only.

With regard to the percentage of protein in seed, no appreciable relation was observed between the character and the doses of manure used.

ACKNOWLEDGMENT

The authors acknowledge with thanks the help received from Dr S. P. Raychaudhuri, Head of the Division of Chemistry of this Institute, for the soil survey work and the chemical analysis of the seed samples done by his staff in connection with this experiment. Thanks are due to Dr P. N. Saxena, Assistant Statistician, for arranging for a considerable portion of the statistical computation to be done in his section, and also to Messrs S. A. Dadlani and G. M. Balchandani for rendering assistance in the field work. The authors express their gratitude to Dr N. Parthasarathy, formerly Head of the Division of Botany, for going through the manuscript and making some helpful suggestions.

REFERENCES

Barbacki, S. and Saloni, K. (1948). Response of cereal varieties to manuring and rate of sowing. *Soils and Fertilizers*, XI, **4**, 262

Crowther, F. (1938). Manurial requirements of cotton varieties. *Emp. Cott. Gr. Rev.* **15**, 21-29

Fisher, R. A. and Mackenzie, W. A. (1923). Studies in crop variation. II. The manurial response of different potato varieties. *J. agric. Sci.*, **13**, 311-320

Gregory, F. G., and Crowther, F. (1928). A physiological study of varietal differences in plants. Part I. A study of comparative yields of barley varieties with different manurings. *Ann. Bot.* (London) **42**, 757-770

Hurst, L. A., Skuderna, A. W. and Doxtator, C. W. (1939). A study of high and low levels of soil fertility response to two varieties of sugar beets. *J. Amer. Soc. Agron.* **31**, 649-652

Lamb, C. A. and Salter, R. M. (1936). Response of wheat varieties to different fertility levels. *J. agric. Res.*, **53**, 129-143

Mooers, C. A. (1933). The influence of soil productivity on the order of yield in a varietal trial of corn. *J. Amer. Soc. Agron.* **25**, 796-800

Pal, B. P., and Parthasarathy, N. (1950). *Proceedings of the Seventh Meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India held at Madras from the 7 to 10 April, 1948*, 116-119

Stringfield, G. H. and Salter, R. M. (1934). Differential response of corn varieties to fertility levels and seasons. *J. agric. Res.* **49**, 991-1000

Worzella, W. W. (1943). Response of wheat varieties to different levels of soil productivity. I. Grain yield and total weight. *J. Amer. S. Agron.* **35**, 114-124

OBSERVATIONS ON *TRICHINOTHRIPS BREVICEPS* (BAGNALL), A LITTLE KNOWN PREDATORY THRIPS FROM SOUTH INDIA*

By A. R. Seshadri, M.A., Assistant Entomologist, Agricultural Research Institute, Coimbatore

(Received for publication on 19 November 1951)
(With Plates I-III)

PREDACEOUS thrips have been reported from different parts of the world from time to time but detailed information on the biology of some of these is based mostly on the works of Yakhantow [1935], Bailey [1939 and 1940], Putman [1942], etc. In India, very little is known on the subject, except for brief references by Ramakrishna Ayyar [1928] and Cherian [1933] to *Scolothrips sexmaculatus* (Perg.) feeding on mites and by Ramakrishna Ayyar [1932], to the doubtful relationship between *Veerabahuthrips bambusae* Ramk. and a scale (*Asterolecanium* sp.). Green in 1913, in a note on web-spinning psocids from Ceylon, makes a passing mention of their being 'attacked and preyed upon by the orange red larvae of a species of thrips'. A similar instance of a thrips being predatory on psocids came to light recently from South India and this paper presents an account of the observations made on this insect. It is quite likely that Green's reference may be to the same species referred to above, since Bagnall [1926] also records it from Ceylon, as being 'carnivorous on psocid'. The similarity of feeding habits in all these cases is indicative and, though known from only a very restricted locality at present, further search is bound to reveal a wider distribution of this little known predator.

Material and methods

(*a*) *Material.* In August 1948, the stems and branches of a number of sapota trees (*Achras sapota* L.) at the Sugarcane Breeding Station, Coimbatore, were found to be profusely covered over with fine and intricately woven silken webbing, strongly suggestive of the work of spiders. Closer examination revealed colonies of psocids living under them. Large numbers of the orange-red pupae of thrips were also found in groups resting under the web in parts of the tree not exposed to direct sunlight, especially in the nodes. The close association of adults and larvae of these two insects in large numbers suggested the possible predatory habit of the thrips and later observations confirmed this. The insect material referred to in this paper was collected from the infested trees.

(*b*) *Methods.* The rearing of this species in the laboratory was but a simple matter. Small vials of sizes 4×1 cm. and $5 \times \frac{1}{2}$ cm. closed by cloth plugs, proved

* This piece of work was carried out when the author was working as Research Fellow in Entomology (Indian Council of Agricultural Research) and the opportunity thus afforded is gratefully acknowledged.

to be excellent cages for the adult and larvae respectively. A sufficient number of the psocids, usually in a parallel stage of development as the predator, was supplied as food once a day. The psocid-web, apart from being a hindrance to the larval stages which got entangled in them, prevented correct observation and had, therefore, to be removed whenever necessary. The thrips were quite active and healthy throughout the period of the investigation. For microscopic examination, permanent mounts were made in Canada balsam after cleaning in oil of cloves. Potassium hydroxide treatment was found necessary for the detailed study of chaetotaxy. Canada balsam proved to be the best mountant for the larvae also, the specimens being preserved without deterioration indefinitely. Faure's medium as advocated by Speyer and Parr [1941] was not so satisfactory. All diagrams were made with the aid of camera lucida.

The adult

Systematic position

This species is a typical *Trichinothrips* Bagn. and is certainly identical with *Trichinothrips breviceps* (Bagn.) according to Dr Priesner to whom specimens were submitted for determination. Priesner [1949, in litt.] gives the following characterization for the genus as different from the one given by Bagnall in 1929 :—

> 'Head broader than long, eyes large, sides convex. Mouth-cone broadly rounded, short. Antennae moderately long, 7-segmented, with incomplete division-line of 7 (beneath), sense-cones long. Major body bristles exceptionally long, fine, knobbed. Legs (inclusive of tarsi) unarmed in both sexes, claw only conspicuous if exserted, fore femora slightly enlarged. Wings comparatively short, broad, evenly wide, with double-fringe. Prothorax strongly transverse, shorter than head. Tube very short, shorter than head, distinctly dilated at base.'

The original description of the species by Bagnall [1926 and 1929] is very brief and based on a single mutilated male specimen collected from Ceylon. This being too inadequate in the light of the discovery of large numbers of both sexes of the insect by the author, the species is redescribed as follows. The female is being described for the first time.

Trichinothrips breviceps (Bagnall)

Bagnall R. S. (1926). *Trichaplothrips breviceps. Ann. Mag. Nat. Hist.* (9)**18**, 550

Bagnall R. S. (1929). *Trichinothrips breviceps. Ibid.* (**10**) **3**, 604

Female. (Plate 1, fig. 1*a*) Length about 1·5 to 2·0 mm. Body and femora dark brown, with the head and the two or three terminal segments darker, often the tube being the darkest region of the body, almost opaque ; tibiae and tarsi uniformly yellow ; the extreme apices of femora also yellowish, gradually merging with the colour of the tibiae. *Antennae*, first segment more or less concolourous with the head, 2 and 3 yellowish brown and 4 to 7 uniformly brown or gradually becoming darker towards the seventh. Eyes dark and the ocelli with red pigment. Wings, especially the fore wings, clouded pale brown throughout their length.

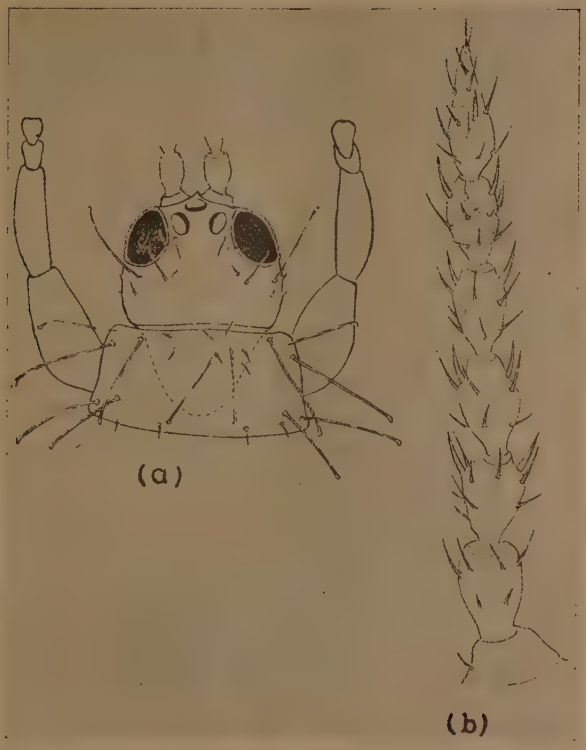


FIG. 1. *Trichinothrips breviceps* (Bagnall)
(a) Female, head and prothorax (b) Female, right antenna

FIG. 2. *Trichinothrips breviceps* (Bagnall)
(a) A few eggs enlarged (b) Piece of twig showing eggs *in situ*

Head distinctly broader than long, broadest behind the eyes and feebly narrowing towards the base, broadly rounded around the eyes in front; vertex slightly produced in the form of a wedge between the bases of the antennae; cheeks finely crenulate, with one or two very minute, indistinct bristles behind each eye.

Eyes large, oval and very prominent, not protruding, about half as long as the head, the interorbital space about $1\frac{1}{2}$ times the diameter of the eye. Ocelli prominent, equidistant from one another, the anterior ocellus directed forwards, the posterior ones bordering the eyes in a level with the middle of the eyes. Occiput finely transversely striate. Postocular bristles very conspicuous, invariably longer than the eye, with distinctly dilated tip. In addition, the dorsal side of the head beset with a few somewhat prominent, pointed bristles symmetrically arranged as shown in the figure (Plate I, fig. 1). Mouth-cone broad and blunt, reaching $\frac{3}{4}$ across prosternum; maxillary palp 2-jointed; labium bluntly rounded at apex and projecting beyond the labrum which is more or less pointed at tip. *Antenna* (Plate I, fig. 1*b*) twice as long as head and to all appearance 7-jointed, probably the distal joint formed by the fusion of 7 and 8, there being an incomplete suture indicating the fusion; first joint the shortest and the broadest, second more or less cylindrical except at the base where it is narrower, third somewhat conical with the broadest portion towards the apex, joints 4 and 5 similar in shape with the broadest region more towards the middle, joint 6 barrel-shaped and joint 7 long, slender and conical with the broadest portion towards the base, this also being the longest segment of the antenna; prominent sense-cones present, a pair each in segments 3, 4, 5 and 6 and a single one in segment 7, not very conspicuous; base of segment 1 covered over by the overhanging vertex.

Prothorax. Slightly shorter than the head, trapezoid in appearance and about twice as broad as long, the basal portion being the broadest; dorsal surface with very faint transverse striations and beset with a number of very long and prominent bristles dilated at tip, 2 in each anterolateral angle, 1 midlateral (placed just behind the outer antero-angular), 2 in each posterolateral angle, one of them being epimeral and a sixth pair along the hind margin on either side of the median line opposite to the tip of the mouth-cone and in a line with the posterolateral pairs; in addition, a number of short pointed bristles scattered over the dorsal surface; the posterolaterals (or posteroangulars), the inner anterolateral (or anteroangular) and the midlateral bristles nearly as long as the prothorax. Fore coxae each with a long bristle, dilated at tip, arising from the ventral surface.

Pterothorax. Distinctly broader than prothorax and about three times its length with the sides slightly arched, and the surface faintly striated anteriorly. At the point of origin of the fore wing, with a long bristle on each side and another pair a little behind towards the median line. *Legs*, fore femora—(of male also)—somewhat enlarged, not armed with spines. *Wings* uniformly broad, with the tip rounded, reaching about the 8th segment in most specimens; each fore wing with three bristles at its base along the anterior margin, but only two of them long and conspicuous and dilated at tip; 7 to 9 fine duplicate hairs present on the posterior margin of

the fore wing very near the tip ; a faint longitudinal vein seen along the anterior and posterior wings.

Abdomen. About as wide as the pterothorax up to the VIIIth segment a pair of prominently long, slender and colourless bristles, dilated at tip, present on the lateral margins of all abdominal segments except IX and X which carry only pointed bristles, the latter being markedly longer than the tube. Tube definitely shorter than the head.

Measurements of female (*in microns*). Head length including interantennal projection 188, from fore-margin of eyes 173, breadth across eyes 211, breadth behind eyes 235 ; length of eyes 90, width 57, interval between the eyes 86, length of cheeks behind eyes 86, postocular bristles 113; distance of postocular bristle behind eye 18. Antennae length 361, measurements of joints, lengths (breadths), 28-31 (b. 43; t. 32), 54 (29), 58 (31), 58 (31), 54 (29), 45 (25), and 77 (22). Pronotum length 157; breadth at base 314; inner anteroangular bristles 111, outer anteroangulars 77, midlaterals 129, inner posteroangular 126, outer posteroangular 133, posteromarginals 86. Pterothorax length 376, breadth 392, fore wing length 785, hind wing 707, basal wing bristles 54, 133 and 155. Abd. seg. IX, bristles, b. 1, 165 ; b. 2, 133 ; b. 3, 144 ; tube length 108, width across base 72, at apex 39, anal, bristles 152, 152 and 144.

Male. Very similar to the female except that it is smaller and slenderer. Body length about 1·4 mm. Head length including interantennal projection 165 from fore-margin of eyes 141, breadth across eyes 169, breadth behind eyes 188, length of eyes 72, width 47, interval between eyes 72, length of cheeks behind eyes 72 ; postocular bristles 97, distance of postocular bristles behind eye 12. Antennae length 330, measurements of joints, lengths (breadths), 25 (t. 29, b. 39), 47 (27), 52 (27), 50 (27), 49 (25), 41 (23) and 72 (20). Pronotum length 125, width at base 251, inner anteroangular bristles 97, outer anteroangulars 65, midlaterals 104, inner posteroangulars 111-114, outer posteroangulars 114-117, posteromarginals 75. Pterothorax length 330, breadth 330, fore wing length 737, hind wing length 660, basal wing bristles 57, 114-117 and 133-137. Abdominal segment IX, bristles b. 1, 189, b. 2, 162 and b. 3, 126 ; tube length 101, width across base 61 and at apex 39. Anal bristles 147 to 165.

Described from numerous males and females (A. R. S. Coll. No. C. 106). Type in the Entomology Section of the Agricultural College and Research Institute Coimbatore, and also deposited in the Zoological Survey of India, Calcutta.

General habits

The insect usually inhabits the bark of the sapota tree and only on one or two occasions were they collected from the leaves and flowers. The surface of the trees, examined with the aid of a hand lens, after removal of the silken web, showed a number of adults as well as larvae crawling about among the psocids and also a few resting in the cracks and crevices of the bark. In these surroundings their colouration blends well with their environment and makes it difficult to detect them even while moving. The smaller branches and twigs,

FIG. 1. Microphotograph of *Trichinothrips breviceps* (Bagnall) feeding on psocid

the axils of leaves, the nodal regions, etc. were equally crowded, but it is the presence of the psocids that primarily determined their distribution in the trees. The psocid web afforded added protection and even inside the rearing vials they were seen to collect together under these webs.

Because of their protective colouration, the best way to collect specimens was to remove scrapings of the bark infested with the psocid and search for them in the laboratory. By nature, the adult is not very active as is the case, usually, with the Tubulifera, but when disturbed they run about and seek places of shelter. They seldom resort to flight even though the wings are well developed. Now and then inside the rearing cages, they were seen to be actively leaping about from one side of the tube to the other with wings widespread, especially on bright sunny mornings. Very often, if provoked, the adults as well as the larvae raise their posterior extremities in a manner suggestive of scorpions and try to hide themselves.

Food and feeding habits of the adult

This species is of interest due to the fact that it is predatory on the psocid '*Archipsocus* sp. probably *recens* Enderlein'.* Probably it may also feed on plant juices and nectar sometimes, since a few specimens were collected from flowers. However, attempts to rear the insects on plant tissue proved failures. Throughout the investigations the adults and larvae fed only on psocids and several generations were reared with complete success. It was observed that, on an average, an adult feeds on about two or three full-grown psocids per day. This is subject to individual variations, for, in many cases only a single one was consumed during the course of 24 hours. Even psocids twice as big as the predator were attacked and the former seemed quite helpless against the same. When young ones alone were supplied, a single thrips required three to five of them per day. However, it has to be said that the adult is not at all a voracious feeder and sometimes completely ignores the presence of its prey nearby. It was a striking spectacle to watch the encounter between the predator and the victim under the binocular microscope. Feeding is done in the following manner (Plate II, fig. I).

As soon as the thrips becomes aware of the presence of the psocid, it runs and seizes the prey and mounts on its back. The raptorial front limbs are used to grasp the victim tight. With the 'tail' curved upwards and the mouth-cone and front limbs closely pressed against the body of the victim, the head of the thrips moves to and fro a number of times, the psocid all the time struggling and beating about its legs. Ultimately, the latter ceases to move and the thrips also settles down to feed. By properly turning and adjusting the rearing vial, the 'stylets' could be seen to be thrust into the body of the victim in this process. After sucking in most of the body contents, the psocids were rolled around with the fore legs and punctured from different sides, evidently to get what little of the contents remained. The feeding process is a very gradual one and in one case it took as much as 1½ hours. If left undisturbed, the predator sucks the victim dry.

* Identification as given by the Zoological Survey of India, Calcutta

LIFE HISTORY AND DESCRIPTION OF VARIOUS STAGES

The entire life history is completed on the bark of the tree itself and all the stages, except the pupae which prefer the more secluded parts of the tree, live among the psocid colonies.

Copulation. Copulation begins in a day or two after emergence. When it is aware of the presence of the female in the vicinity, the male chases it for a short distance and mounts on its back. It clasps the thorax of the female, the forelegs going round the same in a firm grip. The male exhibits excited movements of the posterior tip of the abdomen which is twisted and brought down under that of the female. Subsequently copulation takes place and they remain locked together for a few minutes in this position. The process is repeated a number of times and even after it is completed, the male continues to remain on the female for a considerable time. Copulation sometimes extends, at intervals, over one or two days between the same pair of isolated individuals in captivity. In nature, polygamy is the rule and a single male is able to fertilise a number of females.

Oviposition. Unlike the other Tubulifera generally, eggs are laid singly in isolated places on the surface of the bark, inside crevices along with the psocid eggs or often also suspended in the silky webbing. If a piece of psocid-infested twing is held against light, the minute eggs of the thrips can be seen in the form of whitish specks suspended at different places (Plate I, fig. 2*b*). In the laboratory, the eggs were laid in a similar manner suspended in the webs or attached to the sides of the glass vial or on the surface of the cloth-plug in between the meshes. Just before oviposition the insect remains sluggish for some time and by mild contractions of the abdomen an egg is gradually deposited, the whole process taking only a few minutes.

The pre-oviposition period ranges from 4 to 10 days. If copulation does not take place, the insect usually dies without egg-laying but in a few cases virgin females laid eggs which, however, failed to develop. The egg-laying capacity of the insect varies from 2 to 7. In mounted preparations (in Canada balsam) of females, the ovary can be distinctly seen with 2 to 6 well developed oval eggs and a series of smaller follicles on either side. The egg laying record of five individuals is reproduced in Table I, on next page.

Egg-laying is spread over a number of hours or even days, sometimes 2 to 3 days intervening between laying of successive eggs. In an extreme case, eight days passed before a second egg was laid. The maximum number per day did not exceed individual, not more than one egg being deposited at a time and in most cases the oviposition was completed in 3 to 6 days.

TABLE I

Egg-laying record of five individuals of Trichinothrips breviceps (*Bagn.*)

Number	Adults (both males and females) emerged on	Copulation observed on	Male died on	Number of eggs laid	Female died on	Longevity (days)
1	30-7-48	31-7-48	3-8-48	1 egg on 6-8-48 2 „ „ 8-8 48 1 „ „ 9-8-48 2 „ „ 12-8-48	20-8-48	Male 4 Female 21
2	18-8-48	20-8-48	21-8-48	1 „ „ 28-8-48 1 „ „ 29-8-48 2 „ „ 31-8-48	4-9-48	Male 3 Female 17
3	21-8-48	23-8-48	25-8-48	1 „ „ 26-8-48 3 „ „ 27-8-48	31-8-48	Male 4 Female 10
4	22-8-48	23-8-48	27-8-48	1 „ „ 26-8-48 1 „ „ 27-8-48 1 „ „ 12-9-48	3-9-48	Male 5 Female 12
5	7-9-48	8-9-48	13-9-48	3 „ „ 20-9-48 3 „ „ 24-9-48	27-9-48	Male 6 Female 20

There does not seem to be much variation between individuals in the duration of the various stages of development. During the period of 3 to 4 months, from August to November 1948, when the life history studies were made, data were collected in a large number of cases (not reproduced here for brevity's sake). The life history may be summarised as follows :

Egg stage	6 to 8 days
I Instar larva	3 to 4 days
II „ „	3 to 6 days
Pre-pupa	1 day
I Pupa	1 day
II „	2 to 3 days

The temperature and humidity conditions during the period of study were as follows :

Month	Temperature		Humidity
	Average Maximum	Average Minimum	
August	86·1	71·9	72
September	92·8	70·5	71
October	88·4	70·2	80

It will thus be noted that the complete developmental period requires only from 16 to 23 days and it can be safely presumed that several generations are passed in a year. The egg stage has the longest duration, usually about seven days and the pre-pupa and I pupa are the shortest, both lasting for only 24 hours each. The presence of two pupal stages has been established beyond doubt by means of marking experiments. Distinct characters separate the I and II pupae as described subsequently.

The various stages of the life history are described below :

1. The Egg (Plate I, fig. 2*a*)

The freshly laid egg is dull white, delicate, smooth and transluscent, measuring on an average 0·390 mm. by 0·157 mm., the length ranging from 0·360 to 0·420 mm. and breadth from 0·150 to 0·165 mm. It is elongate and oval, broad and blunt at one end and more pointed at the other. Within 2 or 3 days, the colour gradually changes to yellow. The eye-spots appear on the fourth or fifth day towards the pointed end, sometimes even at the middle. A few days before hatching, the egg assumes a brown colour and the antennae become visible through the egg case, disposed parallel to each other.

At the time of hatching, probably by the movements of the larva inside, a crack appears at the pointed end of the egg. A portion breaks off in the form of a cap-like lid attached to one end like a hinge. Now that the larva is exposed to the outside, it gradually straightens its antennae which are the organs to appear out of the opening first. The larva then wriggles out little by little, the tube being the last portion to come out. The whole process takes from 20 minutes to half an hour. Even after hatching, the larva remains quiescent for some time, evidently for its body to get hardened.

2. Larva I (Plate III, fig. 1*a*)

Pale yellow immediately after hatching, becoming deeper greyish-yellow after a few hours ; eyes dark red. Antenna well sclerotised, segment 1 palest, 2, 3, 4 and 5 with pale areas towards apical one-third, of these 4 and 5 darker ; 6 and 7 uniformly greyish yellow. The usual dark cephalic plates present, the pronotal plates distinct and entire. Other sclerotised areas are the legs, with the femora darker than the tibiae, a small area of the cuticle surrounding the base of each body seta and also the posterior three-fourths of abdominal segments, IX and X.

Newly hatched larva about 0·390 mm. in length ; head comparatively large, broader than long ; mouth-cone broadly rounded reaching the posterior margin of the prosternum ; head cuticula smooth ; length of head including interantennal projection 72, interantennal distance 6, width across eyes 90, width behind eyes about 115 ; preocular bristle 54, outer postocular 50 and inner postocular about 61, all dilated at tips. Antenna length 224, 7-jointed, with the measurements, 22 (b. 36, t. 25), 32 (23), 40 (27), 36 (27), 29 (25), 29 (18), and 43 (14). Compared to the II

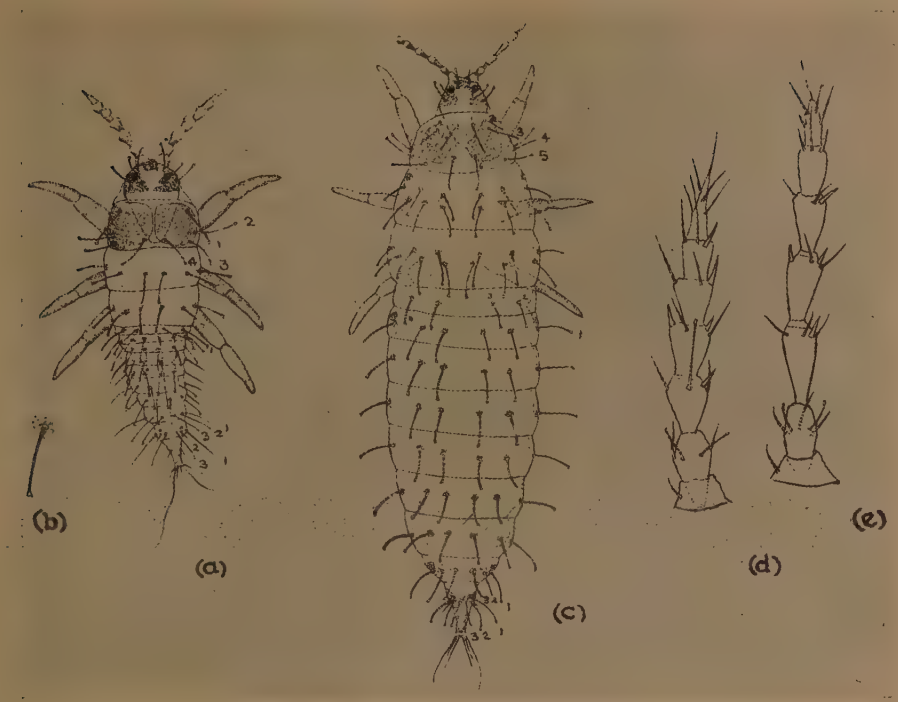


FIG. 1. *Trichinothrips breviceps* (Bagnall)
(a) I instar larva (b) One body bristle enlarged (c) II instar larva (d) and (e) Antennae of I and II instar larvae

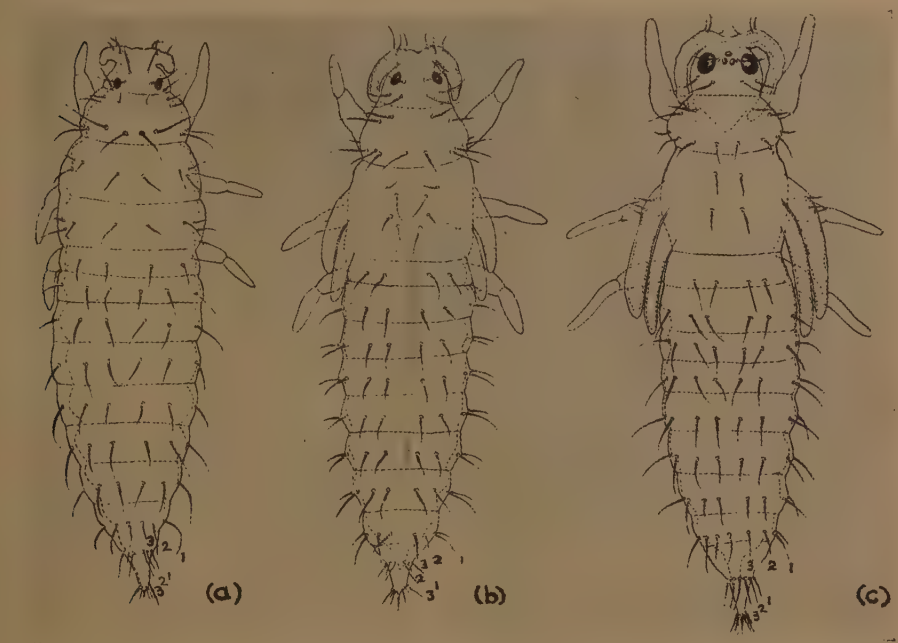


FIG. 2. *Trichinothrips breviceps* (Bagnall)
(a) Prepupa (b) Pupa I (c) Pupa II

instar larva, the joints are broader and reduced, 2, 3, 4 and 7 longer than the others, often seventh being the longest; joint 3 with a long knobbed bristle arising from middle of anterior margin. Sense-cone formula, 3, 0-1; 4, 1-i; 5, 0-1; and 6, 0-1. Pronotum length 108, breadth 198, with 4 pairs of bristles, all knobbed, b. 1, 93; b. 2, 86; b. 3, 79 and b. 4, 90. Mesonotum and metanotum with 3 pairs of knobbed bristles each. Abdominal segment I, b. 1, 72 and b. 2, 79; segment VIII, b. 1, 90 (pointed), b. 2, 79; b. 3, 83; segment IX, width across base 79, b. 1 (outer, pointed), 137; b. 2 (pointed) 36 and b. 3 (inner, knobbed) 90. Length of tube (segment X) 72, basal width 68 and apical width 29, terminal hairs 252. All bristles transparent yellow. (Bristle numbers as indicated in diagram. Measurements given in microns.)

3. Larva II (Plate III, fig. 1*c*)

Colouration essentially the same as in the I instar larva, the body being greyish yellow. Antennal segment 1 palest, segment 2 pale towards apical half, the other segments uniformly grey. Forelegs darker than the mid—and hind legs, femora generally darker than the tibiae. Eyes black. Segment X of abdomen darker than segment IX, both pale at base. Cephalic and pronotal plates well-developed. Other sclerotised areas very similar to I instar; in addition, segment VIII with 2 symmetrical transverse bands leaving the middle pale; base of body bristles not as well sclerotised as in I larva.

Well grown larva about 1·4 mm. in length. Head comparatively small. Body stout and cylindrical and consequently antenna and legs appear slender. Mouth-cone blunt and rounded reaching middle of prosternum. Head length including interantennal projection 104, interantennal distance 18, width across eyes 119, width behind eyes 151. Head bristles dilated at tip, preocular 58, outer postocular 50 and inner postocular 68. Antenna, total length 256, joints more slender and longer than those of the I instar, the measurements being 22 (b. 43, t. 25), 32 (23), 54 (25), 49 (25), 40 (22), 31 (18) and 27 (12); as opposed to larva I where seg. 7 is the longest, here 3 and 4 are longest and 7 is only about half as long as 3; sense-cone formula same as in Larva I. Pronotum length 141, breadth 314, with 6 pairs of knobbed bristles, b. 1, 61; b. 2, 76; b. 3, 90; b. 4, 117; b. 5, 101 and b. 6, 97. Mesonotum and metanotum also with 6 pairs of knobbed bristles each, arranged in two transverse rows of six each along the middle. Abdomen, segment I, b. 1, 90 and b. 2, 86; segment VIII, b. 1, 90; b. 2, 83; segment IX, width across base 108, b. 1, 79; b. 2, 77; b. 3, 72; segment X (tube) length 73, basal width 67 and apical width 32; terminal hairs about 200. All bristles transparent yellow. (Bristle numbers as indicated in the diagram. All measurements in microns.)

4. Prepupa (Plate III, fig. 2*a*)

Body uniformly orange yellow with a deeper shade in the thorax; antennae, sides of head, legs and tube almost colourless or glossy white. Head small, length 118, breadth at base 174; eyes small and black with reddish tinge. Antennae in the form of two short stumps (antennal sheaths) laterally directed, about 90 in

length. Prothorax length 173, breadth 345 separated from the mesothorax by a distinct notch. Meso and metathorax length about 180 and 150 respectively. Chaetotaxy essentially similar to larva II but all setae pointed. Abdomen, segment VIII, b. 1, 148; b. 2, 90 and b. 3, 126; segment IX, b. 1, 94; b. 2, 36; and b. 3, 126; length of tube with anal spear 137. Sclerotisation practically nil. (Measurements in microns.)

5. Pupa I (Plate III, fig. 2*b*)

Colour similar to prepupa, eyes larger, reddish black; ocelli not yet visible. Head length 162, breadth 224, antennal sheaths 187, directed backwards and placed closely apposed to the cheeks laterally and stopping short of the anterior margin of the prothorax. Prothorax length 157 and breadth 345; pterothorax 330, with two pairs of short wing sheaths 241 each, the posterior ones reaching the second abdominal segment. Chaetotaxy of the body similar to prepupa, all bristles pointed. Abdomen, segment VIII, b. 1, 126; b. 2, 108 and b. 3, 126; segment IX, b. 1, 79; b. 2, 39; and b. 3, 108; length of tube with anal spear 166. No sclerotisation. (Measurements in microns.)

6. Pupa II (Plate III, fig. 2*c*)

Colouration essentially the same as the prepupa and pupa I. Head large with dimensions nearing those of the adult head; length 183, breadth across eyes 212, breadth behind eyes 220; eyes very large and oval, more than one-third the length of head, being 76; ocelli distinct and purple in colour. Antennal sheaths very long, curved backwards and downwards, held closely apposed to the cheeks and extending up to the tip of the mouth-cone on the ventral side, length 270. Prothorax length 173, broadest at base 361; pterothorax length 338, wing sheaths much better developed than in pupa I, reaching the third abdominal segment, length being 471. Chaetotaxy similar to Pupa I, all setae pointed. Abdomen, segment VIII, b. 1, 162; b. 2, 126; and b. 3, 144; segment IX, b. 1, 144; b. 2, 155 and b. 3, 162; length of tube with anal spear 220. Sclerotisation nil. (Measurements in microns.)

Just before the final moult, dark pigments begin to appear in certain parts of the body of the enclosed adult, especially on the ventral side. The margin of the wing pads assume a dark shade due to the development of the hairy fringer inside.

Habits of the larvae

The first instar larva, after its body gets sufficiently hardened, begins actively moving about and feeding. This and the second instar are the only feeding stages in development and they usually live in company with the adults among psocid colonies. The mode of feeding is similar to that of the adult except that they are much more voracious. It has been found that the larval thrips feed mostly on larval psocids only and observations indicate that the period and stages of development of the two insects more or less coincide. This enables each stage of the thrips larva to feed on a correspondingly developed psocid. In the laboratory, when

adult psocids were supplied to early larval thrips the latter refused to feed and actively avoided the approach of the former, probably due to their large size. But when partially killed and immobilised adults were supplied, they were attacked and sucked dry. Two or three larvae were sometimes seen to be feeding on the same host. Consequent to their voracious feeding, the size and shape of the larvae increase rapidly till they are almost cylindrical. A full grown second instar, because of its large size is able to overpower even a well developed adult psocid.

The prepupa and the pupae, being the resting stages in development, move away from bright light and take shelter inside crevices, under branches, under thick layers of web or in other regions wherever they were more or less concealed. The tendency is to gather together in groups, sometimes even exceeding 50 in numbers, which appear as orange red patches in different parts of the tree.

Cannibalism. Cannibalism very rarely occurs in this species and was noted only among the larvae and that too in only one instance. Two well grown I instar larvae were seen feeding on an early II instar (immediately after moult) and later, another specimen also was seen in a crumpled state indicating a similar fate. In the adults, cannibalism has not been noted at all.

Moulting. There are five moults altogether giving two active larval stages, one prepupal and two pupal stages. Because of their sclerotised nature, the exuviae of the first and second larvae are thicker and pigmented and do not crumple, thus making the antennae, legs, etc. distinctly visible in larval casts. On the other hand the prepupal and pupal skins are thin, whitish and transluscent and crumple into a shapeless structure.

Just before moulting the larva is sluggish and inactive. The antennae are held close together, the head is kept bent downwards and the body slightly arched. Gradually the tail end of the body and the legs begin to recede from the outer skin and this process is helped by a series of contractions of the abdomen, seen to occur now and then. Since the body is arched downwards, the contractions of the body exert the necessary pressure on the dorsum, as a result of which the skin above the head and the prothorax cracks or bursts in the form of a longitudinal slit. Then follows a slow process of wriggling out after which the old skin is cast off as a single piece. Moulting is completed in about 15 to 20 minutes. Very often the moulted skin is found sticking on to the tip of the tube especially in pupae I and II, their exuviae being very light.

It may also be recorded here that moulting of the first and second larvae have been found to be delayed by a day or two by lack of enough food. This was noted in the case of more than half a dozen specimens which could not be supplied with sufficient food material towards the close of the investigations.

Longevity

The males are always shorter lived than the females; they die soon after copulation, the span of life being 3 to 6 days. The longevity of the female ranged from 10 to 21 days usually but a few of them lived even up to 30 days (Table I).

The exact sex-ratio has not been ascertained but throughout the period of the investigation, individuals of both sexes were available in large numbers and males were roughly as numerous as the females.

Summary

Trichinothrips breviceps (Bgn.), a little known predatory thrips was recently discovered in large numbers at Coimbatore.

A detailed revised description of the insect is given to replace that given by Bagnall. The female of the species is described for the first time.

Observations on the general and feeding habits of the insect were made. The adults as well as the larvae were found in company with psocids and were predatory on them.

The life-history of the predator was studied. Copulation begins 1 to 2 days after emergence from the pupae. Eggs are laid singly and the egg-laying capacity of the insect ranges from 2 to 7. Oviposition is spread over a number of days, sometimes 2 to 3 days intervening between the laying of successive eggs.

The pre-oviposition period ranges from 4 to 10 days. The egg stage lasts for 6 to 8 days, first instar 3 to 4 days, second instar 3 to 6 days, prepupal and first pupa stages one day each and second pupa 2 to 3 days. The duration of the life cycle varies from 16 to 23 days.

The various stages are described in detail.

The longevity of the male ranged from 3 to 6 days, and the female from 1 to 21, under normal laboratory conditions.

Acknowledgment

I wish to express my grateful thanks to Dr Priesner of Cairo for his prompt help in the determination of the species and for the very valuable suggestions regarding its description. Thanks are also due to the Zoological Survey of India for identifying the Psocid material sent to them.

I am indebted to Sri S. Ramachandran, Government Entomologist, Coimbatore, for critically going through the manuscripts and offering useful suggestions for the betterment of the paper and to Sri E. R. Gopala Menon, for his kind co-operation extended to me throughout the work.

REFERENCES

Bagnall, R. S. (1926). Brief descriptions of new Thysanoptera—XVI. *Ann. Mag. Nat. Hist.* (9) **18**, 550

Bagnall, R. S. (1929). A new thrips-gall on Iron wood (*Messua ferrea*) and its inhabitants *Ibid.* (10) **3**, 604-606

Bailey, S. F. (1939). The six-spotted thrips, *Scolothrips sexmaculatus* Perg. *J. Econ. Ent.* **32**, 43-47

Bailey, S. F. (1940). The Black hunter, *Leptothrips mali* Fitch. *Ibid*, **33**, 539-544

Cherian, M. C. (1933). The cholam mite (*Paratetranychus indicus* on sorghum) *Madras Agric. J.* **21 (1)**, 1-6, 1

Green, E. E. (1913). Notes on a web-spinning psocid. *Spol. Zeyl.*, **8**, 72-72

Putman, Wm. L. (1942). Notes on the predaceous thrips *Haplothrips subtilissimus* Hal. and *Aeolothrips melaleucas* Hal. *Canad. Ent.*, **74**, 37-43

Ramakrishna Ayyar, T. V. (1928). A contribution to our knowledge of the Thysanoptera of India. *Mem. Dep. Agric. India Ent. Ser.*, **10 (7)** 255

Ramakrishna Ayyar, T. V. (1932). A new genus and species of Thysanoptera from South India *Rec. Indian Mus.*, **24**, 277-279

Speyer, E. R. and Parr, W. J. (1941). The external structure of some Thysanopterous larvae. Trans. *Roy. Ent. Soc. London*, **91**, 559-635

Yakhantow, V. V. (1935). An ally of the cotton grower, the acariphagous thrips (*Scolothrips acariphagus Yakh.*), (In Russian). *Sotzial, Nanka Tech.*, **12**, 96-98. (Not seen in original)

THREE BACTERIAL DISEASES OF PLANTS

By M. K. Patel, Y. S. Kulkarni and G. W. Dhande, Plant Pathological Laboratory, College of Agriculture, Poona

(Received for publication on 15 January 1952)

(With Plates IV-V)

BACTERIAL leaf spot of betel vine (*Piper betle* L.) commonly found in India, was first recorded in 1896 from Ceylon and the pathogen, described by Ragunathan [1928]. Since then, it has been reported from Madhya Pradesh by Asthana [1947], as occurring on all varieties of betel vine. It was noted in several parts of Bombay State doing considerable damage to lower leaves of attacked plants. The disease is common throughout the year but it is most serious during the rainy weather (June to September) when there is low temperature and high humidity.

Symptoms

The disease first appears as minute water-soaked spots on the lower side of the leaves between the veins (Plate IV, fig. 1). After about 10 days, the spots become visible on the upper surface as dark, round to angular areas, surrounded by yellow zone or halo. It is at this stage that it is often mistaken for leaf-spots caused by *Colletotrichum piperis* Dastur and *Phytophthora parasitica* Dastur. The yellow zone on the upper surface corresponds to the water-soaked area on the lower surface. The spots which in the beginning measure 5 mm. or less when numerous, coalesce forming brown to black areas, of $\frac{1}{2}$ to 1 inch in diameter. Sometimes the dead portions of infected leaves fall out leaving holes. The lesions when marginal often result in deformities and cracking of tissues. Heavily infected leaves are distinctly yellow. Under humid conditions, there occurs an appreciable amount of bacterial gummy ooze. Infection sometimes occurs on petioles and stems, though leaves and leaf-edges form the common place of infection. The incubation period varies from 7 to 10 days.

Morphology

The pathogen which can be easily isolated by the usual poured plate method is a short slender rod with rounded ends, mostly single or rarely in chains of two, with no involution forms. On potato dextrose agar the average dimensions of the bacteria, varying in age from 1 to 2 weeks, are $1{\cdot}6 \times 0{\cdot}9\mu$. It is motile by 1 or 2 polar flagella, gram-negative, non-spore former, capsulated and not acid fast. It stains readily with common dyes.

Cultural and physiological characters

In nutrient agar plates, growth is poor, flat, glistening and colonies measure 4 mm. in four days. In nutrient dextrose agar plates, colonies are round with entire margin, umbonate, 7 mm. in four days, colour Naples-yellow,*striations starting from

*Ridgway's colour standard is followed

the centre. In potato dextrose agar plates, colonies are round, shining, 15 mm. in four days, striations starting from the middle of the colony and coming upto periphery, colour baryta yellow. On potato cylinders, growth is copious but slightly shining, covering the entire surface, colour wax-yellow, cylinder turning orange buff.

The organism liquefies gelatin and is able to digest starch and casein ; colour of the lipolytic medium is changed showing that it digests fat ; litmus reduced ; nitrates not reduced to nitrites ; ammonia and hydrogen sulphide produced ; M. R. and V. P. tests negative ; Loeffler's blood serum completely liquefied in seven days ; sodium chloride tolerant upto two per cent. Thermal death point is about 51°C.

The organism grows well on several synthetic carbohydrate media separately containing one per cent dextrose, lactose, maltose with the production of acid but no gas. It fails to grow in salicin.

Host range

All varieties of betel vine, viz. *kali* or black, *pandhari* or white and *velchi* or small are equally susceptible. Besides betel vine, *Piper longum* L. and *P. hookeri* Miq. are susceptible to varying degrees of intensity. Asthana's [1947] contention that the stomata or wounds are not essential for the entry of the pathogen is not correct as it is only through the undersurface of the leaves that the pathogen enters the host tissues.

Taxonomy and nomenclature

Since the pathogen under study differs in important morphological, cultural and physiological characters from *Bacterium betlis* Ragunathan, it is assigned a

TABLE I

Comparison of important characters of Xanthomonas betlicola *and* Bacterium betle

Characters	*Xanthomonas betlicola*	*Bacterium betle*
Morphology	Motile (Polar) Capsulated	Non-motile Not capsulated
Cultural and physiological characters		
(1) Nutrient agar	Growth, poor, flat, thin, glistening, Diameter 4 mm. in four days. Colour of agar not changed	Honey yellow circular at first, echinulate, raised, smooth. Slightly whitish when old
(2) Potato cylinders	Wax yellow, flowing, glistening, colour of potato cylinder turning orange buff	Honey yellow, viscid mass. The cylinders become of a dull light brown colour. Starch not dissolved
(3) Nutrient broth	Good growth in 24 hours	White membranous scum on the second day. Granular white deposits in broth in regular layers. Medium turns light brown with age
(4) Fermi's solution	Slight growth	No growth
(5) Cohn's solution	Slight growth	Poor growth. White sediment on the surface
(6) Uschinsky's solution	Good growth	Feeble growth

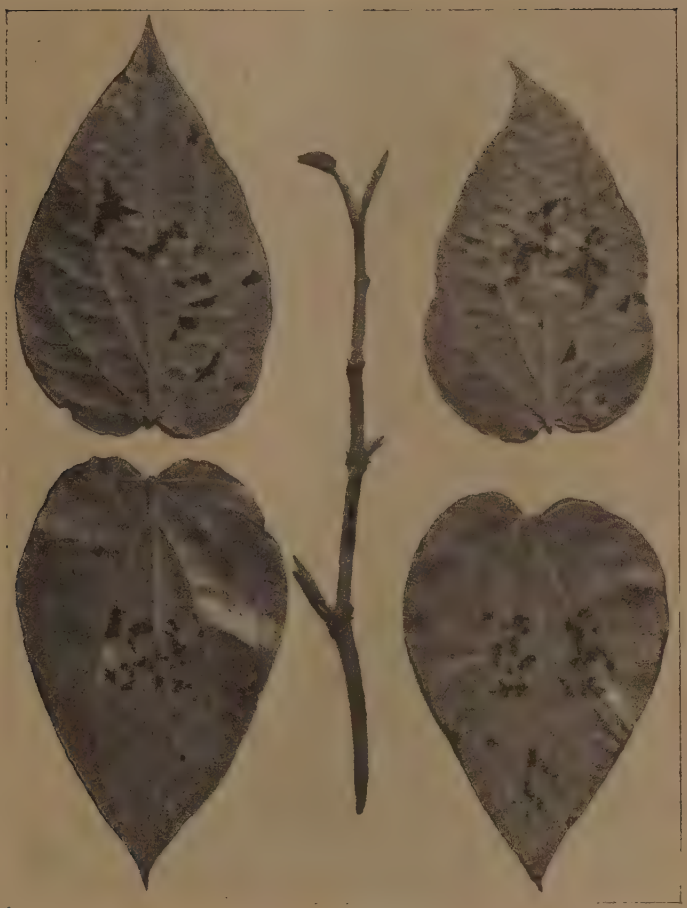


FIG. 1. Leaves and growing shoot of *Piper betle* showing water-soaked angular spots, vein infection and cankers on the young shoot

FIG. 1. Leaf of *Stizolobium deeringianum* showing minute water-soaked spots

FIG. 2. Leaf of *Begonia* sp. showing typical bacterial leaf-spot

specific name of *Xanthomonas betlicola* nov. sp., especially when it produces yellow pigment on solid media and acid in lactose. A comparative statement showing the distinguishing characters of these two organisms is given in Table I.

Technical description

Xanthomonas betlicola Patel, Kulkarni *and* Dhande *sp. nov.* Short rod mostly single measuring 1·6×0·9 μ ; motile by 1 or 2 polar flagella ; gram negative ; non-spore former ; capsulated ; not acid fast ; aerobe ; stains readily with common dyes ; copious and butyrous growth on potato cylinders and potato dextrose agar slant ; colonies on nutrient dextrose agar, Naples yellow with striations ; acid but no gas from dextrose, lactose, maltose ; no growth in salicin ; gelatin liquefied ; starch and casein hydrolysed ; good growth in Uschinsky's but slight in Fermi's and Cohn's solutions ; litmus reduced ; nitrites not produced from nitrates ; ammonia and hydrogen sulphide produced ; indol, M. R. and V. P. tests negative ; fat digested ; Loeffler's blood serum completely liquefied ; sodium chloride tolerant upto two per cent ; slight growth in synthetic asparagine medium ; optimum temperature for growth between 25 and 30°C. ; thermal death point 51°C.

Pathogenic on *Piper betle, P. longum* and *hookeri* producing leaf-spots, causing deformities and defoliation when severe. Found at several places in Bombay State.

A bacterial leaf spot of velvet bean (Stizolobium deeringianum *Bort.*)

Velvet bean, an annual twiner with hairy slender branches, grows under shade in wet places such as river banks. It has fine bristles on the golden-brown and velvety pods which cause much irritation to the skin when touched. The plant has considerable value in the country medicine as a vermifuge. Since the plant grows rapidly and decomposes easily, it is used for green manuring in Mysore. Young shoots are often fed to cattle.

Symptoms. The disease appears on leaves as numerous, small, round and raised water-soaked spots which soon enlarge and become angular (Plate V, fig. 1). Spots when close, coalesce to form irregular lesions. The oily or olive coloured spots in advanced stages become brown to dark brown surrounded by chlorotic areas. Gummy bacterial ooze collects in the centre of the spots as small, round, shining beads or fine scales. Leaf edges, as well as mid and lateral leaf-veins, are also infected. As a result of infection, affected portion of the leaf becomes thin, straw coloured and distorted. Infection of petioles and tender stems results in grayish to black vertical streaks, sometimes 2 cm. in length, which later become jet black and crack.

Morphology. The organism is a short rod with reunded ends, single or in chains of two or three, with no involution forms. It is motile by one or two polar flagella, gram negative, capsulated, non-spore former, not acid fast, and stain, readily with common dyes. It measures 1·6×0·9 μ.

Cultural and physiological characters. On nutrient agar plates, colonies are flat, glistening, 4 mm. in diameter in four days. In nutrient dextrose agar plates colonies are round with entire margins, striations only at the periphery, 7 mm. in four days with creamy yellow colour. On potato dextrose agar plates, colonies are

smooth, round, raised with entire margins, striations starting from the middle of the colony and coming upto periphery, 12 mm. in diam.* after seven days, colour pinard yellow. On potato cylinders, growth is scanty, shining, covering the entire surface, colour maize yellow, cylinder turning gray.

The organism liquefies gelatin and is able to digest starch and casein. Colour of the lipolytic medium is changed showing that it digests fats. Litmus reduced; ammonia and hydrogen sulphide produced; nitrates not reduced to nitrites; M. R. and V. P. tests negative; Loeffler's blood serum slowly liquefied; sodium chloride tolerant upto two per cent; thermal death point about 51°C.

Host range. Several attempts made to infect *Pisum sativum* L., *Glycine max* Merr., *Phaseolus vulgaris* L., *P. aconitifolius* Jacq., *Dolichos lablab* L., *D. biflorus* L., *Cassia tora* L., *Crotalaria juncea* L., *Cajanus cajan* Millsp., *Vigna catjang* Walp., *Desmodium diffusum* DC., *Cicer arietinum* L., *Lathyrus sativus* L., *Ipomoea auricata R.* and Sch., *I. batata L.*, *Physicarpus rugosus* DC., *Arachis hypogaea* L., *Xanthium strumarium* L., *Andropogon sorghum* Brot., *Pennisetum typhoideum* Rich., *Zea mays* L., *Lycopersicum esculentum* Mill., *Gossypium herbaceum* L., *Ricinus communis* L., *Solanum melongena* L., and *Citrus sinensis* Osbeck, failed, whereas the organism readily infected *Stizolobium deeringianum.*

Taxonomy and nomenclature. The morphological, cultural and biochemical characters of the organism isolated from *S. deeringianum* conclusively show it to be quite different from *Ps. stizolobii* reported by Wolf [1920]. A comparative statement giving distinguishing characters of the two organisms is presented in Table II.

TABLE II

Comparison of important characters of X. stizolobiicola *and* Ps. stizolobii

Characters	*X. stizolobiicola*	*Ps. stizolobii*
Symptoms	Bacterial ooze, infection of petiole and stem	No ooze, no infection of petiole and stem
Morphology	Motile	Non-motile (Wolf) Motile (McCulloch)
Cultural and physiological characters		
(i) Nutrient dextrose agar	Colonies flat, glistening, with entire margin, creamy yellow, 4 mm. in four days	Convex, circular, shining colonies, measuring 1 to 1·5 mm. in four days, white, raised with entire margin
(ii) Potato cylinder	Yellow growth, shining, covering entire surface, cylinders turning gray	Growth moderate, white, glistening, substratum not becoming dark, cheesy consistency
(iii) Nutrient broth	Good growth in 24 hours	Slight clouding, no pellicle, no odour
(iv) Fermentation of carbohydrates	Acid in dextrose, slight acid in lactose and sucrose, but not in salicin	No acid in lactose, dextrose, saccharose and glycerin
(v) Gelatin	Liquefied	Not liquefied
(iv) Starch	Hydrolysed	Not hydrolysed

According to a recent classification advocated by Dowson [1949], the organism under reference falls into the genus *Xanthomonas* since it produces yellow pigment on solid media and acid in lactose in contrast to *Pseudomonas* which is characterized as white and by its inability to ferment lactose in a peptone free basal medium. The pathogen is, therefore, named *Xanthomonas stizolobiicola* sp. nov.

Rods, single or in chains, motile, gram negative, capsulated, non-spore former not acid-fast, aerobe and measure 1·6×0·9μ.

On potato dextrose agar, the colonies are circular, smooth, glistening with entire margin, striations starting from the middle of the colony and coming upto periphery, 1·2 cm. diameter after seven days ; colour pinard yellow ; gelatin liquefied ; casein and starch hydrolysed ; lipolytic ; litmus reduced ; ammonia and hydrogen sulphide produced ; nitrites not produced from nitrates ; M. R. and V. P. tests negative ; Loeffler's blood serum slowly liquefied ; sodium chloride tolerant up to two per cent ; optimum temperature for growth 27-30°C. ; thermal death point about 51°C.

Pathogenic on *Stizolobium deeringianum* only, found at Bulsar, District Surat, Bombay State.

Bacterial leaf spot of Begonia

The leaf-spot of begonia was first reported from the United States by McCulloch [1937], while the wilt of the same host from the Continent and England by Dowson, Moore and Ogilvie [1938]. The organism causing these two distinct symptoms is the same, viz. *Xanthomonas begoniae* Takimoto Dowson [1949] and still the symptoms are restricted probably due to climatic conditions. This disease must have been introduced into India with the imported Begonia stock. It was first noticed in Poona in November, 1949, since then it has been observed in Baroda, Bombay, Coimbatore, Mahableshwar, New Delhi and Ootacamund.

Symptoms. The disease is characterized by small water-soaked spots (2 mm.) developing primarily on the lower surface of leaves which later become noticeable on the upper surface (Plate V, fig. 2). These increase in size and when numerous, coalesce and turn yellow to brown. Water-soaked large areas with pale brown and parched centre develop also around the leaf margins. Central depression in the spots is quite prominent on the under surface. Heavily infected leaves may crack at several places and may fall off or keep changing. Wilting has not been observed although the organism has been seen to ooze out from smaller infected veins.

Infection seems to take place through the stomata on the lower side or along the leaf margin especially when there is water deposition. Fairly high temperature and high humidity favour the spread of the disease which is therefore more prevalent during the rainy season and rarely in the summer months.

Morphology. The organism is a short rod measuring 1·9×0·9 μ, motile by a polar flagellum, gram negative, not acid-fast, capsulated, non-spore former and stains readily with common dyes.

Cultural and physiological characters. On potato dextrose agar plates, colonies are smooth, circular, pulvinate, shining, colour pale olive buff, consistency butyrous,

striations starting from the centre of the colony and coming upto periphery; diameter, 1·5 cm. after seven days ; good growth in nutrient broth in 24 hours. On nutrient agar plates, growth poor, dull, pulvinate, olive buff, 5 mm. in four days ; on nutrient dextrose agar plates, colonies are round with entire margin, capitate, cartridge buff ; diameter 7 mm. in four days ; slow growth on potato cylinders which turns gray after eight days. On Patel's medium, growth shining, raised with entire margin, diameter 8 mm. in four days ; does not utilise aspartic acid, arginine, creatine, guanidine, hydrochloride, tryptophane, cystine in the absence of dextrose. Slight growth in synthetic asparagin liquid medium ; no growth in Simmon's citrate and Koser's uric acid media ; non-lipolytic ; sodium chloride tolerant upto three per cent. The organism liquefies gelatin and has a strong diastatic action on starch ; litmus reduced and casein digested ; nitrites not produced from nitrates ; M. R. and V. P. tests negative ; ammonia and hydrogen sulphide produced ; acid but no gas from dextrose, lactose and sucrose ; Loeffler's blood serum completely liquefied in 10 days ; thermal death point about 51°C.

Host range. The organism was able to infect several varieties of Begonia only.

It is apparent from the symptoms and morphological, cultural and physiological characters of the organism isolated from *Begonia* sp. at Poona that it resembles *X. begoniae* (*Ps. flavozonatum* McCulloch).

Summary

Three bacterial phytopathogens, viz. *X. betlicola* nov. sp. *X. stizolobiicola* nov. sp. and *X. begoniae* on *Piper betle*, *Stizolobium deeringianum* and *Begonia* sp., respectively, are recorded for the first time in India.

REFERENCES

Asthana, R. P. (1947). Diseases of *Piper betle* and their control. *Indian Fmg.* **8**, 394-397

Dowson, W. J., Moore, W. C. and Ogilvie, L. (1938). Bacterial disease of Begonia. *J. Roy. Hort. Soc.* **63**, 286-290

—— (1949). Manual of bacterial plant diseases. *Adam and Charles Black*, London

McCulloch, L. (1937). Bacterial leaf spot of *Begonia*. *J. agric. Res.* **54**, 583-590

Patel, M. K., Kulkarni, Y. S. and Dhande, G. W. (1951). Three bacterial diseases of plants. *Curr. Sci.* **20**, 106

Ragunathan, C. (1928). Bacterial leaf spot of betel. *Ann. Roy bot. Gdns. Peradeniya*, **11**, 51-61

Wolf, F. A. (1920). Bacterial leaf spot of velvet bean. *Phytopathology*, **10**, 73-80

INFLUENCE OF THE SUSPENSION OF SUMMER CULTIVATION OF WHEAT AND BARLEY ON THE INCIDENCE OF BLACK RUST

By A. P. Misra, Assistant Systematic Mycologist, Directorate of Plant Protection, Quarantine and Storage, Ministry of Food and Agriculture, Government of India, New Delhi

(Received for publication on 6 February 1952)
(With one text-figure)

WHEAT is a major crop in India and is raised principally in the Punjab, Uttar Pradesh, Madhya Pradesh, Madhya Bharat, Rajasthan, Bihar, Bombay and Saurashtra, mostly during October to March and covers an area of approximately 24 million acres. About 95 per cent of the crop is sown in the plains ; only about five per cent is raised in the hills. Almost every year the wheat crop suffers from the three rusts, black, brown and yellow, caused respectively by *Puccinia graminis tritici*, *Puccinia rubigo vera tritici* and *Puccinia glumarum*. In certain years (depending upon weather conditions) the attack of rusts is severe. In 1946-47 the disease appeared in an epidemic form and caused a loss of about two million tons of food grains [Asthana, 1948]. Because of the destructive nature of the disease, the wheat rust problem has attracted the attention of agriculturists all over the world and various methods of control have been tried. In the U. S. A., Canada and other temperate countries, the barberries act as an alternate host and their eradication is an important control measure. In India, the barberries are restricted to the hills and do not play any part in the annual recurrence of the disease. The aecia commonly observed on *Berberis* sp. in the hills in north belong to *Aecidium montanum* or are connected with the rust on *Agropyron* sp. caused by *Puccinia graminis agropyri* and not with *Puccinia graminis tritici*, causing the black rust of wheat [Prasada, 1947]. In the south, in the Nilgiri and the Palni hills there is no record of the occurrence of aecia of *Puccinia graminis tritici* on *Berberis* sp. In view of this the eradication of barberries in India is not necessary.

Wild grasses which act as collateral hosts of cereal rusts have also not been shown by Mehta to be of importance in the annual recurrence of the disease in India and he considered that the disease appeared year after year in the plains of India from wind borne urediospores which could over-summer in the hilly regions [Mehta 1940, 1942, 1950]. The hilly areas in the north act as immediate foci for the crops sown in the Indo-Gangetic plain. In the south the Nilgiri and the Palni hills act as important foci. In these regions two crops of wheat and barley are raised (one during April and September and the other during October and March). Rust is common in these hills during August to September, i.e. nearly two months before sowing in the plains. The second wheat crop sown during August to September in turn gets infected and acts as a source of the spread of the rust in the foot hills and in the neighbouring area in the plains.

Besides these hilly regions wheat is also raised as a summer crop (during April and September) in certain other parts of peninsular India. This however, comprises

a very small area, approximately 6,000 acres, raised in the districts of Dharwar, Belgaum and Satara in Bombay, Chittaldroog, Chikmaglur, Shimoga and Hassan in Mysore, Nilgiris, Madura (Palni hills), Coimbatore and Bellary in Madras and the Devikolam taluqa in the extreme south and the contiguous areas in the plains of Mysore, South Bombay and North West Madras (Fig. 1). In the hilly areas the crop is sown during April and May and in the rest of the areas in the plains during June and July. The seasons are, however, not clearly defined because the crops raised in the hills at different elevations have different periods of maturity and in the plains the sowings depend upon the availability of water and it may not be unusual that the summer crop over-laps the winter crop or at least the interval between the harvesting of one crop and the sowing of the next is very little in adjoining districts or in different parts of the same district.

Whereas the summer crop in the Nilgiris and Palnis acts as a primary focus, those in the plains act as a secondary source of the spread of the rust. Mehta therefore recommended that to prevent the annual recurrence of the disease in the plains of peninsular India and in the neighbouring States, the sowing of the wheat and the barley crops during summers be altogether stopped, as a short term plan for the control of rust epidemics. A similar measure was also recommended in other countries. In South Mexico where the wheat crop is raised continuously throughout the year, Stakman [1940] recommended the elimination of summer wheat which constituted a relatively small acreage. In Russia, Russakov and Shitikova—Rusakova advocated the elimination of winter wheat in such areas where it served as a source of infection for large acreages of spring wheat [Chester, 1946]. Accordingly a scheme was launched in peninsular India to see how far the recommendations made by Mehta were effective, whether by the stopping of all summer cultivation of wheat and barley in the hills and the plains in the south, the foci for the spread of the rust in these areas were eliminated and whether it minimized or prevented the incidence of black rust on the main crop, raised during October and March, in these areas and the neighbouring States and also to see how far the hilly areas act as primary foci. Consequently the sowing of the wheat and the barley crops (during April and September) was prohibited by legislation in the States of Bombay, Mysore, Madras and Travancore, during the years 1948-51 and observations on the incidence of black rust were made on the crop raised during October to March.

Enforcement of the ban

In 1948, the ban could not be successfully enforced, and about 1,250 acres of wheat and barley were raised in the Nilgiris and Palnis and about 2,500 acres in Hassan, Chikmaglur, Shimoga and Chittaldroog districts of the Mysore State and the Bellary district of North Madras. In 1949, considerable success was achieved. Except for about 400 acres of the unauthorized wheat crop, raised principally in the Chittaldroog district of the Mysore State, there was no general wheat cultivation. This also was destroyed. In 1950, about 200 acres of wheat were raised in the Nilgiris, inspite of the ban. These could not be destroyed due to lack of cooperation from the cultivators. Another, about 100 acres of the unauthorized wheat raised in the Chittaldroog district was, however, promptly destroyed.

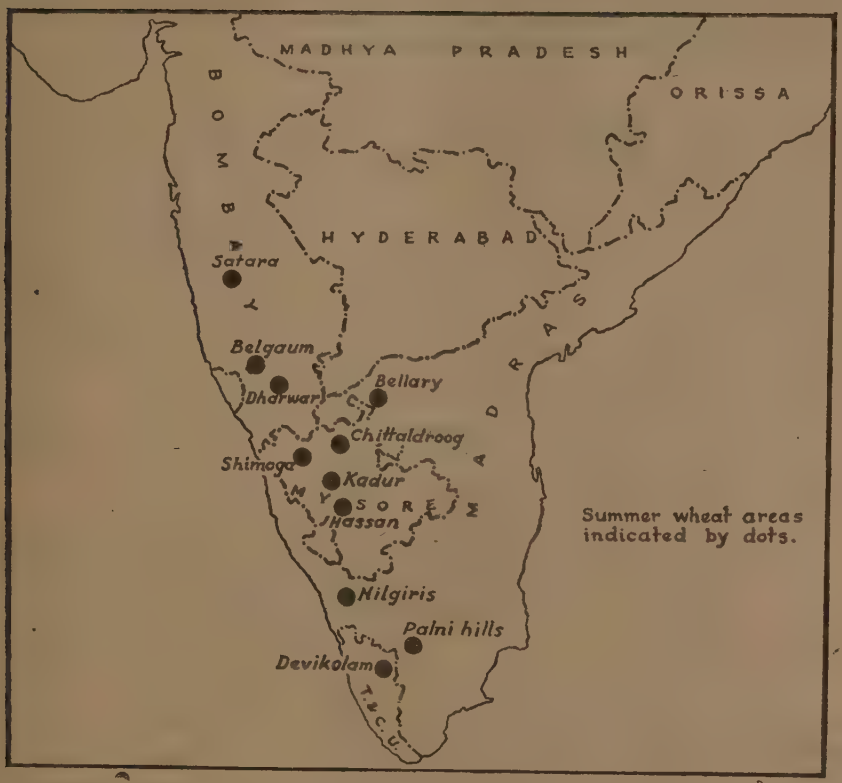


FIG. 1. Summer wheat areas

Experimental results

Observations were made in the States of Madras, Mysore, Bombay and Travancore and also in the neighbouring States of Hyderabad, Madhya Pradesh, Madhya Bharat and Rajasthan during October to March and also at other times to study the effects of the ban on rust development.

In the Nilgiris, black rust was observed, in traces on the summer crop, as early as August to September ; in Mysore state and in the adjoining areas of South Bombay and North Madras (Bellary district) in November ; in the Madhya Pradesh during anuary (in some of the southernmost districts it was noticed in December) and in Rajasthan during February to March (Table 1).

TABLE 1

Time of first appearance of black rust in Nilgiris, Palnis, Mysore, Bombay, Madhya Pradesh and Rajasthan during 1948-51

State	District	1948-49	Time of first appearance of rust during	
			1949-50	1950-51
Madras	Nilgiris	..	..	August*
	Palnis	August*	..	..
Mysore	Chikmaglur	November (1-2nd week)	..	..
	Chittaldroog	November (1-2nd week)	End of November	..
Bombay	Dharwar	November (1-2nd week)	November (3-4th week)	November (Middle)
	Belgaum	November (1-2nd week)	November (3rd week)	*Nil*
	Satara	..	November (4th week	..
Madhya Pradesh	Chanda	December	..	..
	Akola	January	..	..
	Nagpur	January (End)	January (3rd week)	January (2nd week)
Rajasthan	Udaipur	February (1-2nd week)	..	..
	Ajmer	..	March (1st week)	..
	Jaipur	February (2-3rd week)	..	February (Middle)

* Rust observed, in traces, during the last week of August on the summer crop. The exact time of appearance is not known.

It is thus to be seen that black rust appears earlier in southern parts of the country and its appearance is delayed progressively in the north. The data thus corroborate the observations made earlier by Mehta [1940].

Observations on the severity of rust during this period are summarized in Table II.

TABLE II

Average severity of black rust, as observed in certain localities in Nilgiris, Palnis, Mysore, Bombay, Madhya Pradesh, Madhya Bharat and Rajasthan during 1948-51

State	District	Average severity of rust during		
		1948-49	1949-50	1950-51
Madras	Nilgiris*	..	..	Trace
	Palnis	Trace	..	..
Mysore	Chikmaglur	Light-Moderate	..	Trace-Light
	Chittaldroog	Moderate-Heavy	Trace-Light	Moderate
Bombay	Dharwar	Moderate-Heavy	Trace-Very light	Light-Moderate
	Belgaum	Moderate Heavy	..	*Nil*
	Satara	*Nil*	Very Light	..
Madhya Pradesh	Chanda	Moderate-Heavy	..	..
	Akola	Light-Moderate	*Nil*	*Nil*
	Hoshangabad	Trace	*Nil*	Trace
Madhya Bharat	Indore	Trace	..	*Nil*
	Ujjain**	Trace	Trace	*Nil*
Rajasthan	Udaipur	Trace-Very light	*Nil*	*Nil*
	Ajmer	Trace	Trace	*Nil*
	Jaipur	Trace	*Nil*	Trace

* Observations in Nilgiris and Palnis made on the summer crop during August to September.

** In a few irrigated fields the prevalence of rust was 10-100 per cent and the severity trace to 25 per cent.

In 1948-49, in the Nilgiri and the Palni hills (in the extreme south) at altitudes of over 4,000 to 5,000 ft. above sea level, no black rust was noticed during surveys made in December to January. The average weekly temperature in the preceding months of November and December, in these areas, ranged between 39-69°F. and

was possibly low for rust development. In North Madras, Mysore and adjoining areas it ranged between 66-86°F. during November and 55-87°F. during December; there were fairly intermittent rains and the weather was favourable for rust development. Black rust appeared in a fairly severe form in the plains of Madras (Bellary and Coimbatore districts), North Mysore and Bombay and in the neighbouring southernmost district of Madhya Pradesh and its severity progressively decreased and the appearance delayed in the northern districts of Madhya Pradesh. Ultimately it was present only in traces or absent in Madhya Bharat and Rajasthan. January and February were continuously dry and might have been responsible for the relative scarcity of rusts towards the north.

During 1949-50, the weather in November, December and January was unusually dry. There were only a few showers during October. Black rust appeared in a mild form during November in Mysore and only in traces in Bombay and Madhya Pradesh and was absent or in traces in Madhya Bharat and Rajasthan.

In 1950-51, a few plants infected with black rust were observed towards the end of August in the Nilgiris. Later during surveys in December to January it was observed to be rather localized to a great extent around the North Mysore and the adjoining parts of South Bombay (Dharwar, Haveli). It appeared from November to December, in these areas and became moderate to severe in some localities, while in others it remained light or in traces. It was comparatively more severe on earlier sown crop. In Madhya Pradesh it was observed in January and remained very mild or in traces only. In Madhya Bharat no black rust was observed and in Rajasthan it was observed only in traces in one or two localities.

Reports received from several places where the rust was mild or absent indicated that the weather was dry during the critical period of the spread of rust.

Discussion and conclusion

During the three years 1948-51, the scheme prohibiting the summer cultivation of wheat and barley was enforced fairly effectively only in the last two years, when there was relatively little or no rust in peninsular and Central India and in parts of Rajasthan. The weather during the critical period for the development of rust in 1949-50 and 1950-51, was rather dry and as such it could not be determined whether the relative scarcity of rusts was due to the ban or the unfavourable weather or both. However, from a study of the development of black rust in sequence it is to be seen that the rust appears progressively earlier in southern regions. In the Nilgiris it may appear during August to September on susceptible wheats and on barley; in Mysore, Bombay and North Madras usually in November, in Madhya Pradesh during January and in Rajasthan during February and March. Mehta [1940] earlier observed that there might be an abundance of rust on the first crop of wheat in the Nilgiris during August to September and that the second wheat crop sown in the Nilgiris during August to October, in turn might get infected before sowing in the plains. Further, the physiologic races of black rust found in the hills were also common in the plains. While there has been some controversy regarding the Nilgiris and Palnis acting as foci for the spread of the rust, Ramakrishnan [1950] has corroborated

that the black rust occurs in these regions on *vulgare* wheat, *Triticum vulgare* and on barley. During the three years when observations were made, black rust was only sparingly observed in the hills ; the common variety of local wheat, *samba* (*Triticum dicoccum*), which covers more than half of the area in these localities was not found affected. As the development of black rust depends much upon favourable weather (warm climate and fairly intermittent showers or heavy dews), the possibility of the susceptible wheats and barley getting severly infected during August to September (prior to the appearance of the rust in the plains) cannot be overlooked. Even a relatively small amount of inoculum surviving in the hills on the crop or on tillers during the cooler months (October onwards) may serve as a source of infection, which may flare up at lower altitudes where the weather conditions are likely to be favourable for the development and spread of the rust. Nilgiris and Palnis are the probable foci, at least to initiate the infection in the foot hills and the neighbouring areas in the plains.

Another, equally important source of infection may be the summer crop raised in plains, in certain parts of Mysore, Madras and Bombay. Because of the rather long period of sowing and of harvesting, the summer wheat crop in these regions is likely to overlap the winter crop in certain localities, or at least the interval between the harvesting of the summer crop and the sowing of the winter crop is very little. Rust in these regions is likely to pass on from the summer crop to that raised during the winters. It is not unlikely that over-summering may take place, at least occasionally (during April to June as well) in some parts of the Mysore State in relatively cooler localities on tillers or out of season plants or any late sown crop.

Besides the summer crop, there is also the possibility of certain grasses acting as collateral hosts of *Puccinia graminis tritici* in these regions. Even so the importance of a regular crop of wheat or barley during summers, providing a most congenial and continuous host, which may get infected and perpetuate the disease cannot be minimized ; because it may develop an abundance of inoculum which is so necessary for starting an epidemic. It is however, a different thing, if due to the reluctance of the cultivators to suspend the summer crop and the consequent difficulty in the implementation of the ban the scheme cannot be effectively enforced.

While much importance is given to black rust the prohibition of summer cultivation is also likely to prevent the spread of brown rust (fairly common in Nilgiris, Palnis and the plains) and which may also be destructive in certain years.

ACKNOWLEDGEMENT

The writer gratefully acknowledges his indebtedness to Dr H. S. Pruthi, Plant Protection Adviser to the Government of India and to Dr B. B. Mundkur, Deputy Director (Plant Diseases and Weeds) for valuable suggestions during the course of these investigations and writing this paper.

REFERENCES

Asthana, R. P. (1948). Wheat rusts and their control. *Mag. Agri. Coll. Nagpur.* **20**, 1361-43

Chester, K. S. (1946). *The cereal rusts.* Chronica Botanica Company

Mehta, K. C. (1940). Further studies on cereal rusts in India. *Sci. Monogr.* **14**

Mehta, K. C. (1942). Control of rust epidemics of wheat and barley. *Indian Fmg.* **3**, 319-321

Mehta, K. C. (1950). Control of rusts epidemics of wheat in India. *Sci. and Cult.* **15**, 263-270

Prasada, R. (1947). Discovery of the uredo stage connected with the aecidia so commonly found on sp. of *Berberis*, in the Simla hills. *Indian J. agri. Sci.* **17**, 137-151

Ramakrishnan, T. S. (1950). Wheat rusts from Madras. *Sci. and Cult.* **15**, 362

Stakman, E. C., Poppam, W. L. and Cassel, R. C. (1940). Observations on the stem rust epidemiology in Mexico. *Amer. J. Bot.* **27**, 90-99

THE VALUE OF CONSERVATION OF URINE AS A MANURE

By M. A. Idnani, B.Sc., Assoc. I.A.R.I., Assistant Agricultural Chemist, Indian Agricultural Research Institute, New Delhi

(Received for publication on 7 January 1952)

IT is generally recognized that the widespread deficiency of nitrogen in Indian soils is one of the important factors limiting the crop production capacity of our cultivated lands and it has been proved by numerous field experiments that crop yields can be significantly increased by the judicious use of nitrogenous fertilizers and manures alone [Stewart, 1947]. The response obtained on irrigated wheat for example, is of the order of 10 lb. per one pound nitrogen. Paddy yields show increases ranging from 18 to 70 per cent over control. Other crops show similar responses to nitrogenous manuring. This single treatment thus offers considerable scope for improving the low level of crop yields that are obtained in India but lack of adequate quantities of nitrogenous manures to cover the requirements has proved a serious handicap in the extension of plans to achieve this object. It is estimated that at least two million tons of nitrogen are needed annually for manuring our crops. Any plans for meeting this requirement would be on a sound footing if our indigenous resources are explored and utilized to the fullest of their capacity and dependence on imported fertilizer materials is reduced as far as possible.

Manurial wealth in animal excreta and the value of the urine fraction

Farm wastes and cattle excreta still constitute our traditional sources of manure for maintaining fertility of cultivated lands. The total population of cattle in India is estimated at 170 million heads. The value of the liquid and the solid excreta from these, in terms of plant food constituents is shown in Table I.

Table I

Quantity of plant nutrients excreted per year

(Figures in million tons)

	Dry matter	Nitrogen	P_2O_5	K_2O
Dung	186·1	2·29	0·93	1·39
Urine	43·4	3·74	0·11	3·91

Of the mixture of wastes which go in the production of farm yard manure cattle urine is in quantity and quality the most useful fraction containing a number of essential major and trace elements required for plant growth. The dung part of the excreta contains the complex residues of food which have resisted the chemical

and biological processes of digestion. Its constituents are therefore not easily available to plants. The urine fraction on the other hand represents that portion of the ingested food which has been broken down into simple water soluble substances providing readily assimilable elements for growing plants. This has been shown by numerous laboratory as well as field experiments. Heck [1931] applied dung to soil and grew oats, buck wheat, corn and oats in rotation to assess its direct and residual effects on crop growth and yield. The first oat crop recovered only 11 mgm. out of 311 mgm. of dung nitrogen applied and with the three subsequent crops the total recovery of nitrogen amounted to 53 mgm. No increase in yield was obtained in any of the crops. When urine was added along with dung, the yield of the first oat crop was three times the unmanured crop and 276 mgm. out of 345 mgm. nitrogen were assimilated. The subsequent crops recovered additional 74 mgm. nitrogen and registered smaller increases in yield. Jewit and Barlow [1949] in a tethering experiment with cattle similiarly found that plots receiving dung as well as urine gave the same yield of *sorghum* as the plots which received urine alone, indicating that the manurial effect was entirely due to the urine fraction. In laboratory tests, Joshi [1920] found that dung nitrogen did not nitrify at all in eight weeks, whereas urine nitrogen was completely converted into nitrates during the period. These results illustrate the superior manurial value of the nitrogenous constituents in urine and stress has always been laid on the conservation and inclusion of this part of animal waste in the preparation of farmyard manure.

Implications of incorporating urine in the preparation of F.Y.M. and composts

While the importance of inclusion of urine along with dung and litter has been stressed for the preparation of good quality F.Y.M. and compost, the available experimental evidence shows that a considerable part of nitrogen added in this form is apt to be lost during the process of decomposition of organic matter. The loss of nitrogen is particularly heavy in the aerobic process of manure making and may amount to 40 to 60 per cent of that initially present [Acharya, 1940]. Under semi-aerobic conditions in pits or compacted heaps, losses of nitrogen are minimized but take place nevertheless to the extent of 28 to 53 per cent, even under controlled conditions.

In addition to actual losses of nitrogen that occur thus, it has been experimentally shown that one of the most significant changes that take place during the process of decomposition, is the conversion of simple forms of nitrogen into complex proteinaceous forms by the activities of microorganisms [Waksman, 1938]. Hutchinson and Richards [1922] showed that in the decomposition of straw brought about by the addition of simple nitrogenous salts like ammonium sulphate, urea and sodium nitrate, the added nitrogen is assimilated by the microorganic population which is engaged in the breaking down of carbonaceous material and synthesized into their bodies so that there is an absolute increase in organic nitrogen content during the preparation of such manures. It was further determined that for bringing about decomposition of straw, the requirement of nitrogen did not exceed 0·7 to 0·75 parts per 100 parts of straw, so that any excess added over this is liable to loss. Well decomposed organic manures are thus generally characterized by the presence of a maximum of about

two per cent nitrogen in them, the major part of which is in the form of complex microbial and ligno-proteins which are resistent to decomposition and less available to plants than the simpler forms of nitrogen originally present before decomposition [Waksman, 1938]. Barthel and Bengtsson report that under optimum laboratory conditions well fermented manures may liberate little available nitrogen during the course of 12 to 14 months. Jensen [1931] however found that the rate of nitrification of farm yard manure and composts is invariably slow but from 7 to 29 per cent of the added nitrogen may be nitrified during 500 days. The major part of the nitrogen, however, is in too complex a form to become available to plants. Field experiments in India, where the soils are particularly deficient in nitrogen, indicate that bulky organic manures are generally slow acting [Stewart, 1947] and often show little immediate response on crop growth and yield [Idnani, 1949].

These observations indicate that incorporation of urine along with dung and litter and their subsequent decomposition in the preparation of F.Y.M. and composts is apt to result in considerable reduction in the manurial value of the urine fraction due to losses as well as conversion into more complex and difficultly available forms of nitrogen. In order to derive fuller benefit from the simple water soluble compounds of nitrogen in urine, it would therefore appear to be necessary to devise methods of its conservation separate from dung and litter and involving no fermentation by microorganisms which are principally responsible for the breaking down, assimilation and loss of nitrogen occurring in manure heaps.

Experimental

Keeping the above object in view, experiments were conducted to study the conservation of urine by absorbing it in various types of waste materials and then drying them in the sun. This dehydration of urine removes one of the important factors for the development of biological activities which cause fermentation and loss of nitrogen. Human urine was soaked in soil, sand, ash, charcoal-dust, saw-dust, dry leaves, dry dung, paddy husks, waste tea leaves, waste paper, flue dust (cotton) from mills and superphosphate and after saturation the materials were spread out in the sun to dry. The materials were also repeatedly soaked and dried to concentrate the manures and losses of nitrogen during the process were determined. The average results of duplicate experiments are given in Table II.

Table II

Retention of urine nitrogen in various absorbing materials

Material	Absorption capacity per 100 gm.	Number of times saturated and dried	Nitrogen added per 100 gm.	Nitrogen found	Loss per cent
1. Soil	36 c.c.	1	0·328	0·328	*nil*
		2	0·656	0·635	3·2
		3	0·984	0·962	2·2

TABLE II—*(contd.)*

Retention of urine nitrogen in various absorbing materials

Material	Absorption capacity per 100 gm.	Number of times saturated and dried	Nitrogen added per 100 gm.	Nitrogen found	Loss per cent
2. Sand	33 c.c.	1	0·290	0·288	*nil*
		2	0·580	0·571	1·5
		3	0·870	0·846	2·7
3. Ash	133 c.c.	1	1·031	1·000	*nil*
		2	2·062	1·987	2·9
		3	3·093	3·013	2·7
4. Charcoal-dust	125 c.c.	1	0·928	0·925	*nil*
		2	1·856	1·823	1·2
		3	2·784	2·708	2·7
5. Saw-dust	480 c.c.	1	3·309	3·301	*nil*
		2	6·618	6·599	*nil*
		3	9·927	9·886	1·4
6. Dry leaves	333 c.c.	1	2·058	1·982	3·9
		2	4·166	3·913	5·6
		3	6·174	5·684	7·9
7. Dry dung	245 c.c.	1	2·420	2·290	3·3
		2	4·840	4·458	7·9
		3	7·260	6·568	9·5
8. Paddy husk	300 c.c.	1	2·940	2·853	2·9
		2	5·880	5·625	4·3
		3	8·820	8·288	6·0
9. Waste tea	200 c.c.	1	1·928	1·916	*nil*
		2	3·856	3·823	*nil*
		3	5·784	5·726	1·0
10. Waste paper	308 c.c.	1	3·475	3·307	4·8
		2	6·950	6·650	4·3
		3	10·425	9·835	5·6
11. Flue dust (cotton)	500 c.c.	1	3·728	3·616	3·0
		2	7·456	7·236	2·9
		3	11·184	10·988	3·5
12. Superphosphate	40 c.c.	1	0·327	0·370	*nil*
		2	0·744	0·739	*nil*
		3	1·116	1·108	*nil*

The results show that a variety of commonly available materials can be used as absorbants for urine and the major part of the added nitrogen retained in them by drying in the sun. The loss of nitrogen during the process of quick drying is little as compared to the reported losses in the preparation of F.Y.M. and composts.

It has been demonstrated that the concentration of nitrogen in these manures can also be increased without much loss by repeated soaking and drying. The most

significant aspect of this method of conservation is that the nitrogenous compounds of urine are not subjected to any fermentation and are thus retained more or less quantitatively as well as qualitatively in their original form.

Some of the characteristics and limitations of the above absorbing materials when put to this use are discussed below :

Soil. Soil absorbs less than half its weight of urine at a time and would give a concentration of about 0·3 per cent nitrogen after one saturation. When dried after soaking, it forms lumps and is therefore not so suitable for repeated soaking. It is, however, universally available and can be soaked with urine once and used as manure as such or after drying.

Sand. Sand is more suitable than soil for repeated use since it does not tend to form lumps on drying. It is equally heavy and absorbs somewhat less urine than soil. The manure produced after three soakings may contain about 0·9 per cent nitrogen and would be expensive to transport over long distances. Its easy availability makes it more suitable for local use only.

Ash. Ash may be obtained in quantities from kitchens and by burning waste plant materials. It absorbs more than its equal weight of urine and can be repeatedly used for getting a concentrated manure. It has the advantage of containing other plant nutrients like phosphorus and potash for which its manurial value in agriculture is recognized. Ash enriched with urine would serve as an excellent complete manure.

Cattle dung which under the prevailing conditions is for the most part burnt as fuel loses almost all the nitrogen in the process but the residual ash contains the mineral constituents and can be utilized with profit for soaking urine.

Charcoal dust. This waste material is available in urban areas from coal depots, etc. It absorbs twice its weight of urine and can be used several times over to concentrate the manure.

Saw-dust. This is an urban waste material from saw mills. Its value as litter in cattle sheds is well known. It can be repeatedly soaked and dried to get a highly concentrated manure without any loss of nitrogen. As subsequently shown, saw-dust has proved to be the best absorbing material for urine in checking losses of nitrogen. It absorbs nearly five times its weight of urine, thus giving a concentration of about four per cent nitrogen with one saturation.

Dry leaves. Dry broken leaves absorb over three times their weight of urine and after soaking would give a valuable manure, if instead of composting they are dried in the sun. They can be repeatedly used to get a concentrated manure.

Dry dung. This material available with every cultivator may be dried and enriched by using it as an absorbant for urine. Methods of control of losses which may occur in a material of this type are discussed later.

Paddy husk. This waste material is available in large quantities in paddy tracts. It can be used as an absorbant for urine as such or after burning it to ash.

Tea waste. This waste is available in quantities around tea estates and in towns as spent tea leaves. It absorbs twice its weight of urine and can be repeatedly used.

Waste paper. Waste paper torn into bits can be put to profitable use as absorbing material for urine. It absorbs three times its weight of urine and dries easily in the sun. It can be repeatedly used to get a concentrated manure.

Flue dust (cotton). Large quantities of this material are available in cotton mills. Its capacity for absorption is high but is inconvenient for repeated use.

Superphosphate. Phosphatic fertilizers containing nitrogen in addition are proving increasingly useful in agriculture and the use of superphosphate as an absorbant for urine offers a practical method of enriching it before application. The material is not suitable for repeated use as it forms hard lumps on drying. On account of the acidic nature of the material there is no loss on drying and it can be added to other materials in sufficient proportion to check losses.

Losses of nitrogen during slow drying of urine soaked materials and their control

The conservation of urine nitrogen in the above experiments was obtained by drying of urine soaked materials in the sun, immediately after soaking giving little time and scope for decomposition of urine to set in. In practice, however, it may not always be possible to get suitable conditions for such quick drying and materials may have to be left to dry slowly or kept under shade. This practical aspect of the question was investigated and experiments were in the first instance undertaken to determine the extent of loss of nitrogen that may take place under these conditions. In Table III are presented losses of nitrogen which occurred in the course of 10 days slow drying of urine in shade.

TABLE III

Loss of nitrogen after 10 days drying of urine soaked materials in shade

Serial number	Material	Urine-N added per 100 mg.	N-retained after 10 days	Loss per cent
1	Soil	0·421 gm.	0·196 gm.	53
2	Ash	1·348 „	0·280 „	79
3	Charcoal dust	1·684 „	0·918 „	45
4	Waste paper	2·809 „	0·404 „	85
5	Dry leaves	3·254 „	0·723 „	77
6	Saw dust	3·371 „	3·370 „	*nil*
7	Tea waste	1·624 „	0·811 „	50
8	Superphosphate	0·568 „	0·561 „	*nil*

These results show that considerable losses of nitrogen are apt to take place when urine soaked materials remain in moist condition for some length of time. Thus loose earth spread in cattle sheds for absorption of urine is apt to lose quickly the major part of its manurial value if it is dug and utilized after some period. Leaf and straw litters similarly cause fermentation and loss of nitrogen unless they are cleared soon after being soiled. In this respect saw dust has exhibited a remarkable capacity of retaining urine nitrogen completely under conditions of moist storage for 10 days. Losses of nitrogen from urine result chiefly from the conversion of urea into volatile ammonium carbonate by microbiological and enzymatic activities. Inactivation of these can be brought about by the use of salts of heavy metals. [Tauber, 1937]. The use of disinfectants, mineral acids and materials like gypsum and superphosphate has also been found to be effective in preventing losses of nitrogen during the fermentation of urine, dung and compost heaps [Storer, 1897].

Practical application of some of the above results was examined in the following experiments on the control of losses of nitrogen in urine soaked materials, stored in moist condition. The choice of a suitable material for this purpose has to be made with due regard to the toxicity of the preserving agent to plant growth. The use of inorganic salts of heavy metals and organic disinfectants would not be suitable from this point of view and trials were therefore confined to saw dust, sulphuric and hydrochloric acids and superphosphate, the use of which could find practical application in this method of conserving urine. The results obtained in duplicate experiments are given in Table IV.

TABLE IV

Percentage of urine nitrogen lost during 10 days moist storage

Supplementary treatment	Absorbing material				
	Soil	Ash	Leaves	Waste paper	Charcoal dust
Control	53	79	77	85	45
Five per cent saw dust	27	54	67	74	34
Fifteen per cent saw dust	*nil*	*nil*	58	54	*nil*
Sulphuric acid 0·25 c.c. 1100 c.c.	48	76	*nil*	*nil*	*nil*
Hydrochloric acid 0·25 c.c. 1100 c.c.	45	78	*nil*	*nil*	*nil*
Twenty per cent superphosphate	*nil*	*nil*	*nil*	*nil*	*nil*

These experiments showed that urine acidulated with 0·25 per cent sulphuric or hydrochloric acids could be effectively conserved in absorbing materials like leaves, waste paper and charcoal. The mineral acids added in such small quantities were ineffective as preservatives for urine nitrogen in materials like soil, ash, etc., with

which they react chemically and get neutralized. Saw-dust which by itself is an excellent material for soaking and preserving urine nitrogen was also found to control losses of nitrogen when added to the extent of 15 per cent to materials like soil, ash and charcoal with which it can be homogenously mixed. It was, however, not effective when mixed with materials like leaves and waste paper. Superphosphate added to the extent of 20 per cent proved an effective agent for conserving urine nitrogen in all materials.

Effect of urine manures on crop yields

Replicated pot experiments were carried out for two seasons to determine the effect of human urine manures prepared as above on the growth and yield of wheat. Manures were applied at the rate of 60 lb. nitrogen per acre and the yields of grain and straw in 1945—46, given in Table V, illustrate the response obtained with human urine conserved in different absorbing materials.

TABLE V

Human urine conserved in different absorbing materials

Treatment	Yield in gm. from 30 plants		
	Grain	Straw	Total
1. No manure	11·5	23·8	35·3
2. Urine-in-soil	26·6	33·9	60·5
3. Urine-in-saw dust	27·4	37·5	64·9
4. Urine-in-charcoal	28·0	37·3	65·3
5. Charcoal dust alone	13·4	22·5	35·9
6. Ammonium sulphate	22·8	31·6	54·4
Critical difference at one per cent level	5·69	..	7·65

Some of the characteristics of the soil used in the pot experiments are given below :

Total nitrogen	0·04 per cent
Total phosphoric acid	0·057 per cent
Total potash	0·51 per cent
Lime	0·89 per cent
*p*H	7·4
Texture	Sandy loam with 11 per cent clay

Increased yields of grain from 131 to 143 per cent over control were obtained by the use of human urine manures. The treatments proved superior to ammonium sulphate applied at the same rate of nitrogen, indicating that plant nutrients other than nitrogen in urine add to its beneficial effect on crop growth.

Practical application of the results

Although the high manurial value of cattle as well as human urine is generally recognized, it has found little application in agriculture so far due chiefly to lack of some suitable method for its collection and conservation. Experiments reported in this paper show that the common litters *viz.* loose earth, straw, leaves, etc. used in cattle sheds are apt to lose the major part of their soaked nitrogen quickly in the form of ammonia. Composting of soaked litters results in considerable reduction in the manurial value of the original compounds of urine through loss and formation of bacterial and ligno-protein complexes. The easily decomposable nature of urine points to the need for its collection and conservation separate from dung and control of the process of its fermentation into ammonia. The exceptional properties of retaining urine nitrogen possessed by saw dust warrants its utilization as litter wherever possible, alone or admixed with loose earth. The treatment of straw, leaf, soil and such other litters with superphosphate before spreading them in cattle sheds would enable urine to be completely conserved. A fuller benefit from urine-soaked litters could be derived by drying and directly using them as manures instead of putting them in manure heaps to ferment. In *pucca* cattle sheds where urine may get collected as such in cess-pits, the addition of small quantities of mineral acids would prevent losses of valuable nitrogen and the acidulated liquid manure may be conserved by sprinkling this over prepared heaps of the various absorbing materials indicated and allowing them to dry. This manure could be concentrated by repeated sprinkling with urine and drying.

A highly practical method of collecting and utilizing human urine by the use of Agri-San urinals designed by Idnani [1951] makes available an inexhaustible source of a rich manure which has not been exploited so far. The design incorporates the simple principle of absorbing urine directly in a variety of easily available waste materials described in this work. These are filled in a drum or a suitable sized pit. The delivery tube of the urinal is buried inside the material so that urine is absorbed and retained in absence of air, thus controlling its fermentation and all foul smell. When the absorbing material is fully saturated with urine, it is cleared and dried in the sun. For controlling loss of nitrogen during drying, saw dust or superphosphate may be mixed to the extent of 15 to 20 per cent of the material and small quantities of mineral acids may be periodically poured through the mouth of the urinal. The absorbing materials could be repeatedly used to concentrate the manures.

Summary

The urine fraction of animal excreta contains valuable plant food ingredients in simple water soluble forms, easily utilizable by crops. The nitrogenous compounds, in which it is particularly rich, are apt to decompose quickly into ammonia due to which considerable loss in its manurial value takes place in the preparation of F.Y.M. and composts. Also, in the microbiological decomposition taking place in manure heaps, the simpler nitrogenous compounds of high availability are synthesized into complex microbial and ligno-proteins of low availability to plants. These facts

point to the need for separate collection and conservation of urine, involving no fermentation. By allowing urine to soak and dry in various absorbing materials like soil, sand, ash, dry leaves, charcoal dust, saw-dust, dry dung, paddy husk, waste tea, waste paper, flue dust, superphosphate, etc. manures of high availability are obtained, with minimum loss of nitrogen. Saw-dust has been found to be particularly useful in retaining nitrogen completely and can be mixed with other materials to prevent the decomposition of urine. The use of superphosphate and mineral acids in small quantities has been found to conserve nitrogen in absorbing materials like leaves, straw, waste paper, etc.

Practical suggestions for the conservation of human and cattle urine based on this method are described which would enable this fraction to be collected and utilized to a fuller extent. The total potential wealth of nitrogen from these two sources amounts to 5·4 million tons per annum, equivalent in effect to over 27 million tons of ammonium sulphate. This inexhaustible source of a rich manure can thus go a long way in meeting the requirements of the country for nitrogenous manures and increasing our crop yields to the extent its collection is organized and with a potential capacity of making the country more than self-sufficient in these respects.

REFERENCES

Acharya, C. N. (1940). Studies on the hot fermentation process for the composting of town refuse and other materials. *Indian J. agric. Sci.* **10**, 448-472

Heck, A. F. (1931). Conservation and availability of the nitrogen in farm yard manure. *Soil Sci.* **31**, 335-364

Hutchinson, H. B. and Richards, E. H. (1922). Artificial farm yard manure. *Agri. J. India.* **17**, 55-71

Idnani, M. A. (1949). Use of sulphate of ammonia as a fertilizer with special reference to Sind. *Indian Fmg.* **10**, 13-15

———————(1951). Human urine—an unexploited source of manure. *Indian Fmg.***1**, 22-23

Jewitt, T. N. and Barlow, S. K. (1949). Animal excreta in the Sudan Gazira, *Emp. J. Expt. Agri.* **17**, 1-15

Joshi, N. V. (1920). Studies in biological decomposition of cow dung and urine in soil. *Agric. J. India.* **15**, 398-409

Storer, F. H. (1897). *Agriculture in some of its relations with Chemistry*

Tauber, F. (1937). *Enzyme Chemistry*

Waksman, S. A. (1938). *Humus*

COLD STORAGE OF MANGOES

By P. B. Mathur, K. Kirpal Singh and N. S. Kapur, Central Food Technological Research Institute, Mysore

(Received for publication on 15 February 1952)

(With one text figure)

MANGO (*Mangifera indica*) is an easily perishable fruit and strict observation of certain conditions is essential for its successful storage. In the approximately 500 known varieties, a considerable range of physiological and morphological characters is represented, including differences in size, shape, skin colour, fibre, sugar and acid contents and flavour.

For successful storage of mangoes the stage of maturity at which they are picked is of considerable importance. Usually the grafted varieties of mango are not allowed to ripen on the tree.

Cheema and Dani [1934] have defined four stages of maturity as follows :

(1) ' A ' stage. The shoulders are in line with the stem end and the colour of the fruit is oil-green.

(2) ' B ' stage. The shoulders outgrow the stem end and the colour is oil green.

(3) ' C ' stage. The shoulders outgrow the stem end and the colour lightens and

(4) ' D ' stage. The flesh becomes soft and the blush develops.

During the growth of the fruit, the first trace of ' yellow ripening ' colour appears when the shoulders (the part of the fruit situated round the stem end) become level with the point of insertion of the stem instead of sloping away from it. Colouring and softening of the flesh commences near the seed and proceeds outwards. At the time of commencement of the development of colour in the flesh, the seed becomes surrounded first by a cartilaginous and later by a stony endocarp. If allowed to ripen on the tree the later growth consists in the raising of the shoulders and the elevation of the stem on a small mound surrounded by a hollow. The flesh ultimately becomes deep orange throughout [Wardlaw and Leonard, 1936].

Wardlaw and Leonard [1936] have described three stages during the growth and development of the Julie variety of mango (1) almost full grown, green fruits in which the shoulders are level with the insertion of the stem end (2) a later stage where further growth has taken place so that the shoulders are raised above the hollow in which the stem end is inserted and (3) where little or no growth has taken place, but the fruits are on the point of becoming soft.

Banerjee, Karmarkar and Row [1934] stored Neelam variety of mango at 95°F. and 81°F. They found that acidity values fell to a minimum after seven days

whilst total sugars rose to a maximum. Reducing sugars reached a maximum after 12 days by which time, however, the fruit had become rotten. At the storage temperatures of 50°F., 41°F. and 32°F. no appreciable alteration in acidity or reducing sugars occurred in 14 days. At 50°F. there was a rise in total sugars but none at 41°F. or 32°F. during the same period.

According to Wardlaw and Leonard [1936] the best results are obtained when fruit of category 'C' (*i.e.* picked just prior to softening) is maintained throughout at a temperature of 45°F. Under these conditions the flavour is maintained and the wastage is at minimum.

For fruits of stage (2), Wardlaw and Leonard [1936] recommend a storage temperature of 48°F. A temperature of 50°F. causes severe wastage according to the same authors. On removal from cold storage to a temperature of 65 to 70°F., fruits which have not been chilled, ripen normally in the course of 4 to 7 days [Wardlaw and Leonard, 1936].

Cheema, Karmarkar and Joshi [1950] found that fruits of ' A ' stage of maturity (green but just mature) and of ' D ' stage of maturity (ripened on the tree) are unsuitable for cold storage. They, therefore, used fruits of ' B ' and ' C ' stages of maturity (green and mature, and green and fully mature) for their investigations. The ' B ' stage of maturity was found suitable for cold storage. Ripe yellow fruits (eating maturity) of all the varieties with the exception of two varieties, turned brown in cold storage, due to chilling, at all the temperatures from 30°F. to 52°F. Green fruit of ' B ' stage of maturity was chilled at temperatures, below 45°F. Pitting, which was very severe at the low temperatures, was found on the skin of the fruit and the fruit either rotted or did not ripen satisfactorily when it was transferred to 68°F. or to room temperature. It has been found that there is a correlation between the acid content of green fruit and the length of the storage life, the latter being short in the case of fruits with low acidity and long in the case of fruits with high acidity. Alphonso was found to be the best keeper in cold storage.

It has been conclusively demonstrated that mangoes are subject to low temperature injury. Chilling may be manifested in several ways, including the production of definite skin blemishes, failure to develop normal colour on ripening, failure to ripen on removal from cold storage and decline in the resistance to decay organisms.

The aim of investigators working on the cold storage of mangoes in India has been not only to preserve the fruit for home consumption but also to define conditions under which it could be exported to European markets. Cheema and Dani [1934] have reported the details in connection with the experimental exports of the Alphonso variety of mango from Bombay to London. Due to the fact that a more or less constant temperature of 45°F. could not be maintained throughout the sea voyage, the results were not very encouraging. During recent years, however, small quantities of mangoes have been exported from Uttar Pradesh to England by air.

Cold storage chambers

There are four experimental cold storage chambers (each with a capacity of 100 cu. ft. approximately) and two semi-commercial cold storage chambers (total capacity, 1,000 cu. ft. approximately) together with the ' air-locks ' of these two series of chambers, there are available eight temperature ranges for research work. These temperature ranges during the course of work on the cold storage of mangoes were as follows :

(1) 32-35° (2) 35-38° (3) 39-42° (4) 42-45° (5) 47-50° (6) 52-55° (7) 62-65° and (8) 70-71°F.

The relative humidity in chambers Nos. 1 to 6 (*i.e.* the temperature range, 32-55°F.) where the temperatures are controlled, ranged from 85 to 90 per cent. The relative humidities in the ' air-locks ' were as follows :

62-65°F., 70-75 per cent and 70-71°F., 75-80 per cent. A brief description of these storage chambers together with a number of appropriate photographs has been recently published by Mathur and Singh [1952].

Materials and methods

During April to June 1951, three varieties of mango, namely. Seedling, Raspuri [Peter, Naik, 1949] and Badami, [Alphonso, Naik, 1949] were picked from orchards in the neighbourhood of Mysore. Only fruits that were sound and free from blemishes were selected for these investigations. None of the fruits had any stalk-end portions on them. No wrappers were used. The fruits were stored in experimental crates, 15 in.×15 in.×8 in., in dimensions. Only fully grown fruits in which the yellow colour had not developed and which were hard to touch were used for these investigations. This stage corresponds to stage ' B ' of Cheema and Dani [1934] and stage 2 of Wardlaw and Leonard [1936]. In the case of Badami, a later stage, namely, fully ripe, was also used for certain investigations. Fruits in this case were ripened at 62-65°F.

The seedling variety of mango was included in these investigations to find out the optimum conditions for the storage of Seedling mangoes in a green and hard condition for pickle making.

Total solids were determined by means of hydrometer in the juice extracted from the edible portion of the fruits. The corrections for temperature were made.

For the determination of ascorbic acid, 2-5 c.c. of the fresh juice were titrated against a standard solution of 2 : 6 dichlorophenol indophenol. The results are expressed as mg. per 100 gm. edible portion.

For the determination of total acidity, 1 c.c. juice was titrated against N/10NaOH using phenolphthalein as an indicator.

Data and discussion

Data regarding the variations in the physico-chemical constituents of the three varieties of mango investigated are recorded in Table I. These physico-chemical constituents are : average weight of a single fruit, per cent edible portion,

TABLE I

Variations in physico-chemical constituents of mangoes of various varieties ('B' stage of maturity)

Variety	Average weight of a single fruit* in gms.	Percentage of edible portion*	Percentage of Stone*	Brix (Juice) Per cent	Total acidity N/10 NaOH used for 1 c.c. juice in c.c.	Ascorbic acid mg. per 100 gm.
Seedling	128·12	73·46	26·54	8·0	7·210	33·01
Raspuri	245·11	81·74	18·26	12·3	4·410	28·53
Badami	248·56	80·41	19·59	11·1	6·610	39·96

* Mean of 50 fruits

per cent stone, brix, total acidity and ascorbic acid. It is obvious that the percentage edible portion is greater in the Raspuri and Badami varieties as compared to that in the Seedling variety. Badami contains the highest amount of ascorbic acid among the three varieties investigated.

Data regarding the percentage losses in weight in various varieties at various temperatures are presented in Table II. From the point of view of minimum physiological losses in weight (*i.e.* losses due to transpiration and respiration) during storage, 42-45°F. appears to be the most suitable temperature for all the three varieties investigated.

TABLE II

Percentage losses in weight in various varieties of mangoes stored at various temperatures

Storage temperature °F.	Mango variety	Number of fruits	Original weight gm.	Losses after				
				14 days	28 days	42 days	56 days	70 days
32—35	Seedling	12	1560·0	3·14	6·67	10·26	..	..
	Raspuri	6	1605·0	2·68	5·79	9·97	12·40	..
	Badami	6	1514·0	4·46	8·43	11·34	14·93	..
35—38	Seedling	12	1552·0	2·38	8·51	12·70	..	..
	Raspuri	6	1628·0	3·50	6·88	9·89	12·16	16·59
	Badami	6	1677·0	4·47	7·75	11·04	13·84	..
39—42	Seedling	12	1540·0	2·21	4·42	8·64	13·12	..
	Raspuri	6	1575·0	2·79	5·27	8·32	10·65	13·33
	Badami	6	1618·0	3·40	6·86	9·89	13·78	18·55
42—45	Seedling	12	1595·0	2·51	5·27	8·21	11·85	16·80
	Raspuri	6	1579·0	3·48	4·56	7·09	9·55	9·91
	Badami	6	1628·0	2·95	5·59	8·11	11·31	15·36
47—50	Seedling	12	1577·0	2·16	5·83	10·21	14·90	16·80
	Raspuri	6	1620·0	3·52	6·17	8·27	..	..
	Badami	6	1655·0	3·02	6·12	9·67	13·77	..
52—55	Seedling	12	1626·0	3·38	8·49	15·07	..	..
	Raspuri	6	1606·0	4·05	6·73	..	..	..
	Badami	6	1565·0	4·28	8·11	12·40	..	..
62—65	Seedling	12	1645·0	10·58	20·78	..	..	..
	Raspuri	6	1569·0	7·84	..	..	..	..
	Badami	6	1601·0	8·37	..	..	..	..
70—71	Badami	6	1658·0	10·47	..	..	..	..

TABLE III

Changes in percentage total soluble solids (Brix) in various varieties during storage at various temperatures

Storage temperature °F.	Mango variety	Initial reading	After				
			14 days	28 days	42 days	56 days	70 days
32—35	Seedling	8·0	8·4	11·0	12·5	..	..
	Raspuri	12·3	15·1	13·1	15·2	15·3	17·7
	Badami	11·2	11·5	12·0	12·6	13·7	13·8
35—38	Seedling	8·0	8·5	12·5	12·0	..	..
	Raspuri	12·3	15·0	16·0	15·0	15·2	17·2
	Badami	11·2	11·5	11·8	12·5	13·5	14·0
39—42	Seedling	8·0	8·7	12·0	12·8	13·0	..
	Raspuri	12·3	16·2	17·0	16·2	17·0	17·4
	Badami	11·2	11·6	12·8	13·4	14·0	15·0
42—45	Seedling	8·0	8·0	12·2	11·5	12·0	13·0
	Raspuri	12·3	16·7	17·0	17·2	17·5	17·0
	Badami	11·2	11·3	11·5	14·0	14·0	15·0
47—50	Seedling	8·0	8·3	12·5	12·0	13·0	..
	Raspuri	12·3	16·2	15·5	16·5	..	..
	Badami	11·2	13·1	14·5	14·6	15·0	15·0
52—55	Seedling	8·0	12·5	14·5	..	..	..
	Raspuri	12·3	16·4	17·8	..	..	..
	Badami	11·2	11·5	13·0	15·4	..	..
62—65	Seedling	8·0	17·0	..	..	..	..
	Raspuri	12·3	19·5	..	..	..	..
	Badami	11·2	15·5	..	..	..	..

TABLE IV

Changes in total acidity (CCS. N/10 NaOH used for 1 c.c. juice) in various varieties during storage at various temperatures

Storage temperature °F.	Mango variety	Initial reading	After				
			14 days	28 days	42 days	56 days	70 days
32—35	Seedling	7·2	7·0	7·0	6·0	..	..
	Raspuri	4·4	3·5	3·5	3·4	3·3	3·2
	Badami	6·6	6·5	6·6	6·0	6·4	6·0
35—38	Seedling	7·2	7·2	6·5	5·7	..	..
	Raspuri	4·4	4·1	3·9	3·8	3·3	3·0
	Badami	6·6	6·7	6·6	6·4	6·5	6·4

TABLE IV (*contd*).

Changes in total acidity (CCS. N/10 NaOH used for 1 c.c. juice) in various varieties during storage at various temperatures

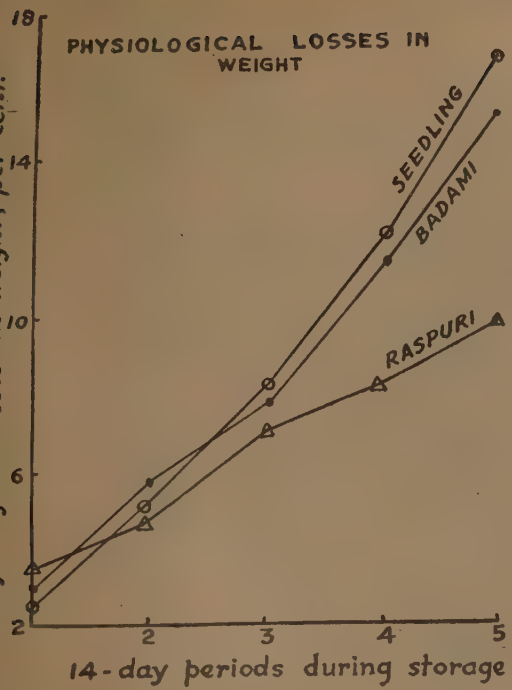
Storage temperature °F.	Mango variety	Initial reading	After				
			14 days	28 days	42 days	56 days	70 days
39—42	Seedling	7·2	6·6	6·5	6·3	5·9	..
	Raspuri	4·4	3·6	3·4	2·9	2·8	2·6
	Badami	6·6	6·4	6·5	6·2	5·8	5·4
42—45	Seedling	7·2	7·2	6·4	5·9	4·4	3·5
	Raspuri	4·4	3·9	3·6	3·1	2·6	2·8
	Badami	6·6	5·9	5·7	5·5	5·3	5·3
47—50	Seedling	7·2	6·0	5·7	5·2	4·6	..
	Raspuri	4·4	3·8	2·6	2·3	..	..
	Badami	6·6	5·2	4·5	3·4	3·5	..
52—55	Seedling	7·2	4·8	4·0	..	..	..
	Raspuri	4·4	2·7	0·8	..	..	..
	Badami	6·6	4·9	1·9	1·3	..	..
62—65	Seedling	7·2	4·8	..	..	..	..
	Raspuri	4·4	0·5	..	..	..	..
	Badami	6·6	3·5	..	..	..	..

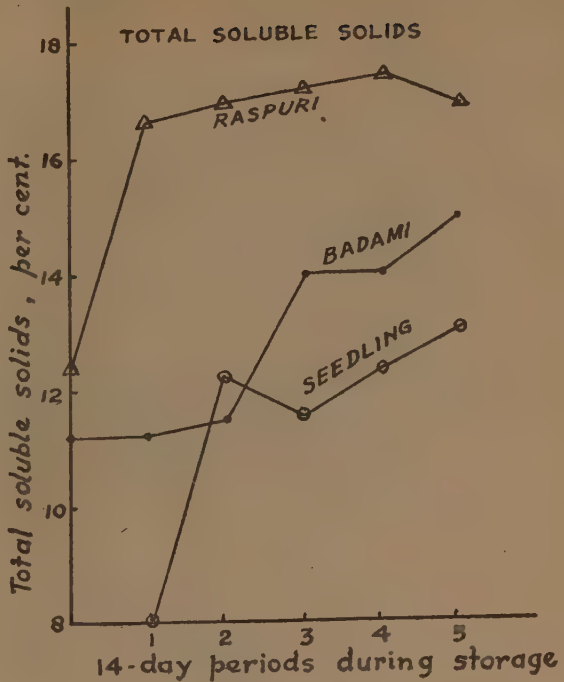
TABLE V

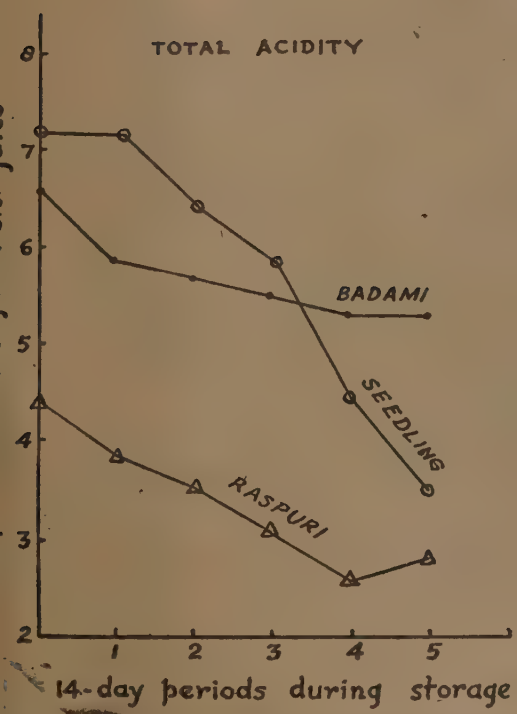
Changes in ascorbic acid content (mgm. per 100 gm. edible portion) in various varieties during storage at various temperatures

Storage temperature °F.	Mango variety	Initial reading	After				
			14 days	28 days	42 days	56 days	70 days
32—35	Seedling	33·01	20·45	0·74	0·65	..	..
	Raspuri	28·53	22·75	19·19	9·59	4·94	1·56
	Badami	39·96	26·24	11·52	2·91	0·93	..
35—38	Seedling	33·01	32·33	18·79	1·10	..	..
	Raspuri	28·53	26·17	16·78	14·94	4·83	1·42
	Badami	39·96	29·18	14·37	2·47	0·88	..
39—42	Seedling	33·01	31·77	15·60	10·87	1·72	..
	Raspuri	28·53	24·29	18·48	12·94	7·57	2·09
	Badami	39·96	34·69	26·84	17·13	10·26	..
42—45	Seedling	33·01	31·18	25·58	22·60	8·77	0·72
	Raspuri	28·53	25·48	14·08	13·96	7·46	3·25
	Badami	39·96	35·34	31·37	30·70	24·86	17·96
47—50	Seedling	33·01	31·42	20·59	15·93	0·82	..
	Raspuri	28·53	16·19	10·35	7·44	..	..
	Badami	39·96	36·83	26·94	12·79	6·97	..
52—55	Seedling	33·01	30·41	19·22	..	..	..
	Raspuri	28·53	13·19	7·27	..	..	..
	Badami	39·96	27·38	18·78	9·77	..	..
62—65	Seedling	33·01	27·95	..	..	..	..
	Raspuri	28·53	7·12	..	..	..	..
	Badami	39·96	20·43	..	..	..	..

Data regarding the changes in percentage total soluble solids in various varieties during storage at various temperatures are presented in Table III. It was found that there is an increase in the percentage of total soluble solids during storage in all the varieties and at all the temperatures under investigation. This can be explained as due to losses of moisture during storage.







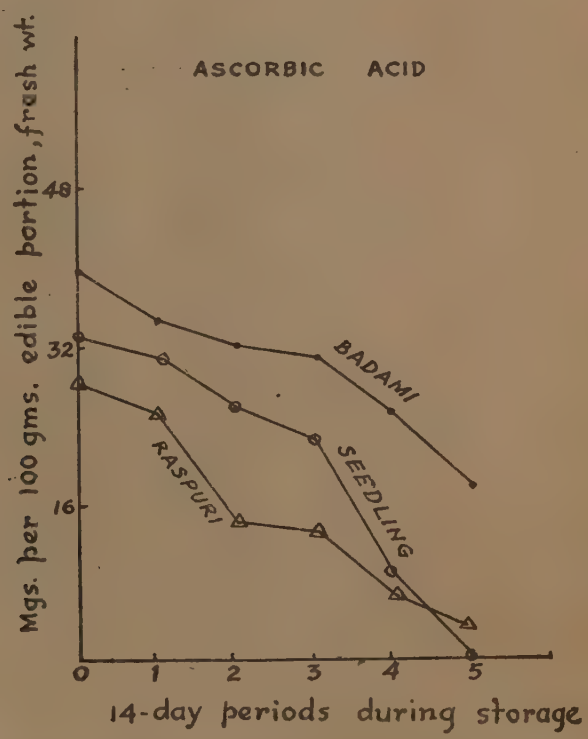


FIG. 1. Physiological losses in weight and changes in total soluble solids acidity and ascorbic acid content in three varieties of mangoes stored at 42-45 F.

In Table IV are recorded the changes in total acidity in various varieties during storage at various temperatures. There is a progressive decrease in total acidity in all the varieties and at all the temperatures.

Data regarding the changes in ascorbic acid content in various varieties during storage at various temperatures are recorded in Table V. There is a progressive decrease in the vitamin C content in all the varieties and at all the storage temperatures.

Data regarding the physiological losses in weight, changes in total soluble solids, acidity and ascorbic acid in the three varieties of mango, namely Seedling, Raspuri and Badami at 42-45°F. are graphically shown in Fig. 1.

The general condition of the three varieties of mango during storage at various temperatures is described below. Observations were made at 14 days intervals.

SEEDLING MANGOES

After 14 days	32-35°F., 35-38°F., 39-42°F., 42-45°F.	Looked fresh, colour green, no adverse effect
	47-50°F.	Greenish tinge showed slight change towards yellow
	52-55°F.	Fruits changed colour to yellow
	62-65°F.	All fruits ripened with attractive yellow colour
After 28 days	32-35°F., 35-38°F.	All fruits showed discoloration of the skin due to chilling injury
	39-42°F.	Some fruits were still fresh in appearance, others showed shrivelling and discoloration towards the stem end, because of the oozing out of the sap
	42-45°F.	Fruits still fresh and hard
	47-50°F.	Fruits still fresh, some showed development of yellow tinge and also became slightly soft
	52-55°F.	Fruits got softened and over-ripened
	62-65°F.	Fruits started rotting
After 42 days	32-35°F., 35-38°F.	All fruits showed advanced stage of discoloration due to physiological breakdown
	39-42°F.	Most of the fruits showed discoloration and some were badly shrivelled towards the stem end
	42-45°F.	Fruits still fresh and green
	47-50°F.	Most fruits had softened, with some of them rotting
	52-55°F.	Fruits started rotting
After 56 days	39-42°F.	Most of the fruits showed physiological breakdown followed by rotting
	42-45°F.	Fruits had softened and started to rot
	47-50°F.	Fruits had softened and rotted
After 70 days	42-45°F.	Fruits had softened and had rotted

Raspuri mangoes

After 14 days	32-35°F.	Fruits still hard, green and fresh. A few showed physiologica breakdown (pitting)
	35-38°F.	Fruits still hard, green and fresh
	39-42°F.	
	42-45°F.	Fruits still hard, green and fresh. No sign of low temperature injury
	47-50°F.	Fruits still fresh in appearance and a few fruits had started to ripen and showed slight change of colour
	52-55°F.	Almost all the fruits had started to ripen
	62-65°F.	All the fruits had turned soft and ripened. A few had started to rot
After 28 days	32-35°F.	Fruits still green and hard but a few fruits showing low temperature injury (pitting)
	35-38°F.	
	39-42°F.	
	42-45°F.	Fruits still green and hard. Few had slightly softened without change in colour
	47-50°F.	Fruits had turned soft and changed in colour
	52-55°F.	Fruits had ripened accompanied by a change in colour. Most had started to rot. (Anthracnose)
After 42 days	32-35°F.	Fruits showed signs of physiological breakdown. In certain fruits the sap was oozing out from the stem end
	35-38°F.	
	39-42°F.	
	42-45°F.	Fruits still in good condition with slight appearance of black spots (Anthracnose)
	47-50°F.	Almost all the fruits had developed black spots (Anthracnose) and therefore, unmarketable
After 56 days	32-35°F.	Most of the fruits showed physiological breakdown
	35-38°F.	
	39-42°F.	Most of the fruits showing spot rots (Anthracnose)
	42-45°F.	
After 70 days	35-38°F.	All fruits showed pronounced physiological breakdown
	39-42°F.	

Badami mangoes

After 14 days	32-35°F.	Fruits still green and fresh and remained hard. Sap was oozing out from the stem ends of few fruits
	35-38°F.	
	39-42°F.	Fruits still green and fresh and remained hard
	42-45°F.	
	47-50°F.	
	52-55°F.	Few fruits turned slightly soft. Slight softening without changing colour
	62-65°F.	All fruits turned soft. Some fruits changed colour
	70-71°F.	All fruits had ripened and developed a good attractive yellow colour

After 28 days	32-35°F.	First signs of physiological breakdown (pitting) appeared
	35-38°F.	
	39-42°F.	Fruits still green and hard. Sap had started oozing out
	42-45°F.	
	47-50°F.	Fruits still in good condition showing slight change in colour
	52-55°F.	Fruits had turned soft along with the development of spots due to rot (anthracnose)
After 42 days	32-35°F.	Further development of physiological breakdown
	35-38°F.	
	39-42°F.	Oozing out of sap had become more pronounced and fruits showed a shrivelled condition
	42-45°F.	
	47-50°F.	All fruits were very much affected by the spot rot (anthracnose)
	52-55°F.	More advanced development of anthracnose spots. Fruits had turned almost brown
After 56 days	32-35°F.	All fruits showed discoloration due to physiological breakdown
	35-38°F.	
	39-42°F.	Fruits still in good condition except oozing out of sap
	42-45°F.	Same as above with appearance of anthracnose spots
	47-50°F.	Almost all the fruits had turned brown (anthracnose)
After 70 days	39-42°F.	Anthracnose spots had started appearing. Also discoloration due to physiological breakdown. Heavily infested with blue and green moulds
	42-45°F.	

Storage of ripe fruits of Badami variety (ripened at 62-65°F.) at lower temperature

In the case of Badami variety, besides the 'B' stage of maturity, another stage of maturity, namely, fully ripe fruits, was also investigated with regard to its storage behaviour.

Eighty fruits were kept at 62-65°F. for ripening and after a fortnight when all the fruits had ripened, they were transferred to cold storage temperatures, 32-35°, 35-38°, 39-42°, 42-45° and 47-50°F. Observations were made over a period of six weeks.

After 14 days' storage, fruits from all the storage temperatures except 47-50°F. were found to be in good condition and gave satisfactory organo-leptic tests. Fruits from 47-50°F., however, got overripened and overrun by rots (anthracnose).

After 28 days' storage, fruits from 32-35°F. and 35-38°F. showed slight discoloration, but the taste was good. Fruits from 39-42° and 42-45°F. were still in good condition both in regard to appearance and taste.

After 42 days, fruits from 32-35°F. and 35-38°F. were further discoloured due to low temperature injury. On cutting, it was observed, however, that the flesh was of normal colour but gave a flat taste. Fruits from 39-42°F. also showed discoloration due to low temperature injury. The taste was flat but better than in fruits from 32-35°F. and 35-38°F. Fruits from 42-45°F. showed brown patches due to anthracnose. The flesh was of normal colour but gave disagreeable taste.

TABLE VI

Changes in physico-chemical constituents in Badami mangoes ripened at 62-65°F. (15 days) and then stored at 32-35°F. and 39-42°F.

Physico-chemical constituents	Original	After ripening (15 days at 62-65°F.)	After six weeks at	
			32-35°F.	39-42°F.
Brix	11·2	15·5	14·0	15·0
Acid (CCS. N/10 NaOH used for 1 c.c. juice)	6·6	3·5	0·30	0·50
Ascorbic acid (mgm. per 100 gmm. edible portion)	39·96	35·13	33·04	30·61

A few data obtained in connection with the changes in certain physico-chemical constituents in Badami mango ripened at 62-65°F. and then stored at 32-35°F. and 39-42° F. are presented in Table VI. As is evident from Table VI one advantage of cold storing mangoes after ripening at 62-65°F. is that the ascorbic acid content does not decrease during subsequent cold storage at 32-35°F., and 39-42°F. This point, however, needs further investigation.

Effect of storage at low temperatures on subsequent ripening at higher temperatures

Raspuri Mangoes. After 14 days' storage at 32-35°, 35-38°, 39-42°, 42-45°, 47-50° and 52-55°F., 20 fruits from each temperature treatment were placed for ripening at two temperatures, *viz.* 62-65°F. and 70-71°F. Ten fruits were placed at each of the two ripening temperatures. Condition of the fruit after 14 days storage at the various temperatures had already been described. Daily observations were made with regard to these ripening tests. After four days' storage at both the ripening temperatures, fruits from 32-35°F., 35-38°F., 39-42°F. were still unripe, with slight change in colour to yellow which resulted in accentuating the low temperature injury. Fruits from 42-45°F. showed slight change in colour but were free from signs of low temperature injury. Fruits from 47-50°F. and 52-55°F., however, ripened perfectly and were free from any blemishes. Fruits from these two temperatures had an excellent taste. After seven days the fruits from 42-45°F. storage ripened perfectly and were in a good condition as determined by organo-tests, but fruits from the lower storage temperatures showed increased signs of low temperature injury and ripening occurred from outside towards the stone. Fruits from the higher temperatures showed signs of over-ripening and had started to rot. After 14 days the fruits from 32-35°F., 35-38° F. and 39-42°F. had ripened uniformly but were still acidic in taste. But they were unmarketable due to skin blemishes caused due to low temperature injury.

After 28 days' storage at 32-35°F., 35-38°F., 39-42°F., 42-45°F. and 47-50°F. fruits were placed at the room temperature (78-79°F.) for ripening.

Observations were made daily for a week, and it was found that fruits from 32-35°F. 35-38°F. and 39-42°F. failed to ripen uniformly because the flesh next to the stone did not ripen and remained acidic, and the low temperature injury marks (pitting) spread along with ripening processes. Fruits from 42-45°F. ripened quite uniformly and were free from low temperature injury. Fruits from 47-50°F. developed anthracnose spots along with the ripening.

After 56 days' storage at 32-35°F., 35-38°F., 39-42°F. and 42-45°F. fruits were placed at room temperature (73-79°F.) for ripening. Observations were made daily for a week. Fruits from all the temperature treatments developed dark brown colour along with ripening.

Two of these three varieties, namely Peter (Raspuri) and Alphonso (Badami) were used by Cheema, Karmarkar and Joshi [1950] also in their investigations on the Cold Storage of mangoes. These authors used 28 varieties obtained from different states in India. However, they had used Peter (Raspuri) from Madras State and Alphonso (Badami) from Bombay State whereas in these trials these two varieties were picked from orchards in the neighbourhood of Mysore town.

Cheema, Karmarkar and Joshi [1950] reported that Peter (Raspuri) of ' B 'stage of maturity ripened normally at 68°F. or at room temperature after four weeks cold storage at 48°F. With regard to the Alphonso (Badami) the same authors reported that the fruit of ' B ' stage of maturity remained in a firm and green condition for about nine weeks at 45°F. These fruits ripened well when transferred to 68°F.

No relation between the original acid content of the various varieties and their storage lives could be established in these investigations. Cheema, Karmarkar and Joshi [1950] found a positive correlation between acid content of the various varieties and their storage lives (calculated on 10 per cent wastage basis).

Storage disorders and diseases

Low temperature injury appeared as pitting in Raspuri variety and discoloration followed in the end. But in the case of Seedling and Badami mangoes only discoloration was noticed and no pitting.

Anthracnose (*Collectotrichum gloesporioides*) was the main cause of the end of the storage life at 47-50°F, and 52-55°F. From pin points the disease spreads into bigger patches rendering the fruit unmarketable. The trouble also appeared at 39-42°F. and 42-45°F. but to a lesser degree. At the higher storage temperatures green mould (*Penicillium digitatum*) and blue mould (*P. italicum*) were also noticed on decaying fruits.

Summary and recommendations

During April to June 1951, three varieties of mango, namely Seedling, Raspuri (Peter) and Badami (Alphonso) were picked from orchards in the neighbourhood of Mysore. Only fully grown fruits in which the yellow colour had not developed and which were hard to touch were used for these investigations. As a result of these investigations, the following conclusions have been arrived at :

(1) The percentage edible portion is greater in the Raspuri and Badami varieties, as compared to that in the Seedling variety. Badami contains the highest amount of ascorbic acid among the three varieties investigated.

(2) From the point of view of minimum physiological losses in weight (*i.e.* losses due to transpiration and respiration) during storage, 42-45°F. appears to be the most suitable temperature for all the three varieties investigated.

(3) It was found that there is an increase in the percentage of total soluble solids during storage in all the varieties and at all the temperatures under investigations.

(4) When fruits of ' B ' stage of maturity are stored, there is a progressive decrease in total acidity and the ascorbic acid content during storage in all the varieties and at all the storage temperatures under investigation.

(5) At 42-45°F. the Seedling mangoes were still fresh and green after 42 days of storage and could be used for the making of pickles.

(6) Raspuri variety can be stored for a maximum period of 42 days at 42-45°F. in a green condition.

(7) Badami variety can be stored for a maximum period of 28 days in good condition at a temperature of 47-50°F.

(8) Badami mangoes ripened at 62-65°F. could be stored at either 39-42°F. or 42-45°F. for a period of 28 days. Freshly-picked Badami mangoes can be ripened satisfactorily at 62-65°F. in 15 days.

(9) Raspuri mangoes stored at 42-45°F. for 28 days could be ripened uniformly at room temperature (73-79°F.).

(10) Low temperature injury appeared as pitting in Raspuri mangoes and discoloration followed in the end, while in the case of Seedling and Badami mangoes only discoloration was noticed and no pitting. Anthracnose was the main cause of the end of the storage life at 47-50°F. and 52-55°F. Since the infection with spores takes place in the orchards, the storage life of mangoes can be prolonged even at these temperatures if strict rules of orchard sanitation are followed.

ACKNOWLEDGMENT

Our thanks are due to Dr V. Subrahmanyan, Director, of our institute for his keen interest in these investigations.

REFERENCES

Banerjee, B. N., Karmarkar, D. V. and Row, G. R. (1934). *Agric. Live-stk. India.* 4, 36

Cheema, G. S. and Dani, P. G. (1934). *Dept. Agr. Bombay. Bull.* 170

———— Karmarkar, D. V. and Joshi, B. M. (1950). *Indian J. agric. Sci.* **20**, 259

Mathur, P. B. and Singh, K. K. (1952). *Indian Fmy.*, **1** (12), 18

Naik, K. C. (1949). *South Indian fruits and their culture* Vardachary, P. Madras

Wardlaw, C. W. and Leonard, R. E. (1936). *Low Temp. Res. Sta., Trinidad, Mem.* 3

REVIEWS

ESTIMATION OF SIZE OF ECONOMIC HOLDINGS IN PUNJAB

(Published by Economic and Statistical Organization, Publication No. 6, Government of Punjab (India), 1952)

THIS is an attempt to estimate the size of an economic holding in the Punjab. It has a three page explanation followed by several tables. The concept of what is an economic holding is difficult to reduce into an empirical formula. Definitions put forth are not satisfactory. It is generally understood as an area which can yield enough to meet the necessities and ordinary comforts of a cultivator's family. Again the concept relates economic achievement with the standard of living, and the latter is difficult to measure. Economic measurement of standard of living has not been satisfactory as it generally includes judgments of an individual on social values. In this study no attempt is made to go into such controversial questions. Certain basic assumptions are made and on the basis of those assumptions an attempt is made to determine the number of acres needed to produce certain cash income per annum.

The data presented in this study was collected by sight investigators who were working under Sri R. L. Anand, Economic and Statistical Adviser to the Government of Punjab. The inquiry was conducted in 28 villages, selected at random sampling method, and in each of these villages about forty persons were interviewed. The study shows that the economic holding varies from district to district and for different types of soil conditions, and availability of irrigation. Whereas seven to eight acres of well irrigated land may be considered economic, it takes 12 to 18 acres of land which depends on rainfall only.

No one can question the soundness of the statistical approach to this problem. The technique involved is good, but one wonders whether some of the basic assumptions are sound. It was assumed that the family has to pay no rent, the entire holding is under cultivation, the yield would be normal, unaffected by unfavourable climatic conditions, that all the food for the family came from the holding and there was no subsidiary income. The assumption that the yield would not be affected by unfavourable conditions is a bold one and it is sufficient to offset the validity of the conclusion. However, one must recognize that this is a pioneer study to reduce theories into figures and hence due credit must be given. (H.S.A.)

THE FRUIT GARDEN DISPLAYED

By Patric M. Synge

(Published by the Royal Horticultural Society and Geoffrey Comberlege at the Oxford University Press, Vincent Square, London SW 1, December, 1951, Price 8s. 6d.)

THE 'Fruit Garden Displayed' is a cloth bound and richly illustrated hand book which readily serves the amateur fruit grower with a clear and concise

presentation of the fundamental principles underlying the practice of fruit-growing.

The initial chapters dealing with the planning of a fruit garden, the choice and preparation of site and the principles of manuring are very informative. The book is divided into two parts, Part I deals with soft fruits and Part II treats some important temperate fruits like apples, pears, plums and gages, peaches and nectarines, sweet cherries, acid coherries and figs. The last five chapters deal with the neglected fruit garden, pests and diseases, fruit spraying calender, fertility rules in fruit planting and a list of recommended varieties. The subject matter is profusely illustrated throughout and is, therefore, easy to follow by the amateur for which the book is principally written. With the instructions given in the book, it is easy for him to control the performance of trees by intelligently applying the pruning, ringing and other cultural operations.

The present edition is based on the collective contributions made by experienced fruit growers of England and the invaluable knowledge accumulated by the research staff of the East Malling Research Station, the Long Ashton Research Station, Wisely Gardens, John Iunes Institution and the Ditton Laboratories. The Royal Horticultural Society of England has usefully combined the available information from these sources and presented it in this Book in a simple and lucid form with vivid illustrations.

In spite of the fact that the book deals with temperate fruits only that are not largely grown in tropical countries, its value for fruit growers in these countries is none-the-less small because of the information on fundamental principles governing fruit production. Still more interesting and valuable is the vivid account of each operation supported by clear photographs. The book should prove a very helpful guide to students as well. (S.S.)

CO-OPERATION IN KODINAR

(*Published by the Indian Society of Agricultural Economics, Bombay-1, Price Rs. 6*)

THIS book 'Co-operation in Kodinar' brought out by the Indian Society of Agricultural Economics embodies the results of a fairly comprehensive and interesting study of the socio-economic structure and conditions of the Kodinar taluka of Bombay Sta te and the part played by the co-operative movement in various fields of economic and social life of the people of that taluka.

The book is divided into three parts. The first part, which gives a survey of the physical features, natural resources, prevalent occupations, and customs and development agencies of the region, provides a useful background elucidating in a general way the existing socio-economic patterns and the possible directions of development. In the following part is surveyed the progress of the co-operative movement and its impact on the life of the people. Part III of the book gives an outline of a plan for further development of the economic resources of the area and reorientation of the co-operative movement so as to make it capable of improving the standard of life of the rural masses.

In Kodinar taluka the co-operative societies have not been isolated single-purpose societies but they have been units closely linked with Kodinar Co-operative Banking Union, which has been performing multifarious activities. Like the rest of India, the movement in the taluka flourished up to 1930, suffered a setback during depression, resulting in land transfers from some of its members to money-lenders, and expanded after 1940. On the side of achievements the movement has touched all the villages of the taluka, encouraged thrift, lowered the rate of interest, increased average size of members, holdings, popularized improved farming practices, effected social reforms and by these means raised economic condition of about 80 per cent of its members. Among the unsatisfactory features of the movement in the taluka have been mentioned, its failure (*a*) to cover not more than 24 per cent of the rural families, (*b*) to meet credit needs of all its members as many as 30 per cent of whom still borrow from money-lenders and (*c*) to improve the lot of its medium and small-cultivator members, the average size of whose holdings actually declined during depression.

The book also contains an interesting and thought-provoking introduction by Mr. Manilal B. Nanavati, the President of the Indian Society of Agricultural Economics. He makes two important suggestions for re-orientation of the co-operative movement. In the first place, he would like the co-operative movement to collaborate with the State on honourable terms in the great task of agrarian reconstruction. Secondly, he would like the co-operative movement to bring under its compass all aspects of human life and in short to become a rural rehabilitation movement. In this latter task, however, he suggests concentration of effort on 'all problems of a few' in preference to tackling only a few problems of many. These are important suggestions which deserve careful consideration both by co-operative enthusiasts and planners. They bring to the fore at once the potentialities which lie before the movement in the great task of rural reconstruction while at the same time drawing attention to the need of putting our expectations from the movement in a short period at reasonable levels. (M.S.)

IMPROVING THE WORLD'S GRASSLANDS

By A. T. Semple

(*Published by Leonard Hill Ltd., 1952, London, Price 10s. 6d.*)

THIS is a study compiled by A. T. Semple of the Agricultural Division of the Food and Agriculture Organization. It is based on information furnished by 55 grassland workers belonging to different countries of the world and on the advice tendered by several other workers of whom 26 are mentioned.

The study covers almost the entire world as it refers to the grasslands of the tropic, the sub-tropic and the temperate regions of both the hemispheres. Because of the varied geographical conditions of the different parts of the world, the vastness of the area to which it pertains, and the different aspects of improvement to which reference is made, it cannot be expected of this study to deal with any aspect or

region at great length. However, several important aspects concerning the development of grasslands of the world are briefly dealt with.

The study begins with a consideration of the importance of grasslands in regard to their kind, their relation to other lands, and of grass in relation to agriculture. The other aspects, the study deals with, are the improvement of natural grasslands specially from the herbage aspect, management of livestock on which to a large extent depends the better or poorer condition of the grassland, seeding and fertilizing, burning, etc. These are dealt with in such a manner as to furnish information on practices followed in different countries of the world. The programme of improvement adopted by leading pastoral countries such as Australia, New Zealand, Switzerland and the United States of America are briefly referred to. This information should be of help to workers in other countries in outlining programmes to suit their own conditions. A chapter is devoted to additional source of forage available from trees and shrubs. Among those described a special mention may be made of *Koa haole* or *Koo babul* (*Leucaena glauca*) a multi-purpose legume. It can serve as a live hedge, can prevent soil erosion, can be used for green manuring, can provide fuel, and its leaves and pods can be fed as a rich source of nitrogen to cattle. Useful information is given on utilization of hay and silage as supplemental feeds. The last chapter appropriately refers to the need for research on the problems of grassland improvement and integrated development of grassland, arable land and the livestock, which if undertaken in countries like India would pay ten-folds in meeting the fodder deficit which affects a large part of the country and in the development of its impoverished and much neglected cattle.

It is interesting to note how in such a short space of 147 pages, information covering almost every part of the globe has been included. The study can most appropriately be considered a digest of information on the present condition and future possibilities of grassland development in various parts of the world. Not the least important part of the publication is the bibliography given at the end of each chapter for further reading.

The compiler deserves the thanks of grassland workers of the world for bringing together information scattered in so many journals and reports not easily accessible to all.

The get up of the publication is praiseworthy, especially the inclusion of so many excellent illustrations. The get up could have been further improved if an attractive cover in colours with an illustration of good grassland had been provided to the publication. (L.S.S.K.)

LES BLE'S TENDERS CULTIVES EN FRANCE

(Triticum Vulgare Vill)

By Pierre Jonard

(*Published by the Institut National de La Rechorche Agronomique, Paris, 1951 unde the Ministre de L' Agriculture*)

IN a short introduction the author brings out the necessity of publishing a catalogue of improved wheat varieties for release to farmers and sale by the seed traders.

The central station for plant Breeding at Versailles maintains the varieties cultivated in France in order that they may be described in the form of a catalogue. Such a publication was brought out in the form of a monograph in 1936. The present volume gives the description of 137 varieties and thus claims to bring the varietal position more or less up-to-date. The author draws attention to the difficulty of classifying wheat varieties solely with the help of ear characters. He further points out that vegetative characters will have to be used for the purpose of classification. He has actually adopted this procedure in the book.

The author says that the information given is mostly valid for the northern region of France.

The book contains three descriptive chapters. The first chapter deals with (i) the botanical classification of the genus *Triticum* and (ii) the classification of the genus into agricultural varieties based on agronomical characters. The genetic origin of the French varieties of wheat also finds a place in this chapter.

The second chapter contains a rather detailed account of the morphological characters that have been used in the book for the purpose of varietal classification. These are grouped into (*a*) ear characters and (*b*) vegetative characters.

The third chapter is devoted to a description of the physiological characters such as resistance to frost, reaction to fungus diseases, length of vegetative period, response to cultural operations, etc. and grain quality.

The third chapter to be followed by a bibliography of about 170 references. The actual classification of the French varieties of wheat is done on the basis of (i) ear characters and (ii) vegetative characters. There are two keys provided respectively for these two classifications. These are followed by a summary of the characters (ear characters, vegetative characters and physiological characters) of each one of the 137 varieties that have been included in the classification.

Photographic plates of the ears of 30 varieties are given (Plate No. XV has been wrongly numbered as X). (G.S.M.)

FOOD AND POPULATION AND DEVELOPMENT OF FOOD INDUSTRIES IN INDIA

(*Published by the Central Food Technological Research Institute, Mysore, 1952*)

THE success of a democracy depends largely on how well-informed people are about the important problems of the day and how much they care for impressing their points of view on the law-makers. This book serves to present before the reading public the opinions of a number of experts on food and population, the two most serious and interlinked problems facing the country. These opinions have a factual basis and hence deserve to be widely known.

The book comprises all the papers read and discussed during two symposia arranged by the Central Food Technological Institute, Mysore, in May 1951. The first part

of the book covering the symposium on Food and Population deserves special attention. It contains analysis of the demographic situation in India by such experts as, Dr C. Chandra Sekar, Director, United Nations Office for Population Studies, New Delhi, and Dr S. Chandrasekhar of Baroda University. The picture they draw is alarming ; at the present rate of population growth, the population of India will be doubled in about 35 years. Efforts at increasing food production will not lead to a solution of the food problem unless earnest and immediate efforts are made on a wide scale to check the growth of population. An estimate of the urgency of the situation can be made from the figures presented by Dr K. Mitra, of the Directorate General of Health Service to the Government of India ; if the population continues to grow at the present rate, the country will require by 1956 an increase in the annual food production to the extent of six million tons of various items of food in addition to 48 million maunds of fluid milk. Prof. Shri Ranjan, Prof. Noronha, Sir Datar Singh and other speakers discussed the ways and means of increasing food production. It was pointed out by Sri A. K. Yegna Narayan Aiyer that if unrationed subsidiary foods like tapioca, yams, *singara*, nut, cooking plantains, etc. could be popularised, a part of the insufficiency in staple foods could be immediately made up. Dr Venkitasubramanian and Dr De of the Indian Institute of Science, also stressed the possibility of reducing our food deficit by utilising food from unusual sources and waste materials.

The second part of the book covers the symposium on the development of 'Food Industries in India', and presents a valuable survey of our food industries, their problems and their potentialities. More than half the papers at this symposium were presented by representatives of different food industries and the rest were mostly from research workers in food technology. This was a happy combination and led to the discussion of a wide range of topics like Vanaspati, Fruit and Vegetable Preservation, Production and Processing of Fish, etc. on one hand and Quality Control in Food Manufacture, Technical Personnel in Food Industry, Future of Food Processing in India, etc. on the other. One point that emerged clearly from this symposium was that the Central Food Technological Research Institute and other institutions will have to carry out extensive research projects and render all possible technical assistance to Indian food industries to enable them to develop rapidly and efficiently.

The Central Food Technological Research Institute should be congratulated on holding such successful symposia and on publishing a well-edited account of them. (J.C.G.)

GAZETTEER OF AGRICULTURAL AND FORESTRY RESEARCH STATIONS IN THE BRITISH COMMONWEALTH

(Published by Commonwealth Agricultural Bureau, Farnham Royal, Bucks, England 1952, Price 30s.)

THE Gazetteer, the first of its kind, gives a list of agricultural research stations throughout the British Commonwealth including a list of such stations in the Republic of Ireland. It includes over a thousand research stations, laboratories and

experimental farms which come under the purview of agriculture or forestry. All ranges in climate and soil types are represented in the research stations listed. In latitude, the range is from Fort Simpson at 62° North, in the north west territories of Canada, and the research stations around Aberdeen, Scotland at 57° North, through the equatorial stations of East Africa, Malaya and the islands of the Western Pacific, to the stations at Gore and Mosgiel at 46° South Island of New Zealand. Altitudes range from the Cereal Sub-station at Lahaul at 10,500 ft. in the Himalayas and the Kenya Forestry Department Plantation which range up about the same elevation, down to the Plant Virus Research Unit at Cambridge, England, which conducts its investigations at 4 ft. below sea level. Possibly the greatest range of altitude at any one station is that conducted at the University College, Bangore North Walles, from sea level to 3,000 ft.

Soil types which are described in some detail for most research stations, are obviously, many and various. Likewise, extremes of rainfall exist from 146·51 inches at Rice Experiment Station, Karimganj, Assam (India) to two inches at Mirpur Khas in Sind (Pakistan). Temperatures range from 50°F. in the Alberta to 120°F (average) in Central India.

The value of the 'Gazetteer' is very much enhanced by the inclusion of details about location, climate, altitude, soils, crops researches and postal address of each institution.

Two indexes *viz.* I. An alphabetical index of research stations and II. An alphabetical index of subject of research have been given at the end to help the research workers.

The Institutions dealt within the Republic of India are 285, and 150 pages are devoted to them.

The research notes given under each Institute are indeed very helpful to a research worker. These include summary of the previous work along with the type of problems which are being tackled at each station and the abstract of results achieved.

This is a very useful guide to a research worker in the fields of Agriculture and Forestry and also as a helpful reference book in any Library, Agricultural Institute and Research Station. Executive Council of Commonwealth Agricultural Bureaux has done real service to the Commonwealth and Republic of Ireland by bringing out this valuable publication containing very useful information.

It should prove a helpful Encyclopedia for scholars going abroad for higher studies who can get first hand information of the problems of research being investigated at different places and plan their programme accordingly. Every research worker, Station, Institute, University and Agricultural College should possess a copy of this. (S.S.)

MGIPC—M—30 AR/52—10-7-53—880.